The risk and return characteristics of sector-specific real estate investment trusts in the Asia-Pacific

Author:
Lin, Yu-Cheng

Publication Date:
2021

DOI:
https://doi.org/10.26190/unsworks/22355

THE RISK AND RETURN CHARACTERISTICS OF SECTOR-SPECIFIC REAL ESTATE INVESTMENT TRUSTS IN THE ASIA-PACIFIC

YU-CHENG LIN

A thesis in fulfilment of the requirements for the degree of Doctor of Philosophy

School of Built Environment

Faculty of Arts, Design & Architecture

January 2021

Thesis/Dissertation Sheet

Surname/Family Name	:	LIN
Given Name/s	:	YU-CHENG
Abbreviation for degree as give in the University calendar	:	PhD
Faculty	:	ARTS, DESIGN & ARCHITECTURE
School	:	BUILT ENVIRONMENT
Thesis Title	:	THE RISK AND RETURN CHARACTERISTICS OF SECTOR-SPECIFIC REAL ESTATE INVESTMENT TRUSTS IN THE ASIA-PACIFIC

Abstract 350 words maximum: (PLEASE TYPE)

Asia-Pacific Real Estate Investment Trusts (REITs) have become a significant listed property sector in the international property investment space. One of the prominent attributes of Asia-Pacific REITs is that sector-specific REITs have played a prevailing role in the Asia-Pacific REIT markets compared with diversified REITs. This unique trajectory of sector-specific REITs aligns with the discussion of specialisation value in the finance literature. However, there is a paucity of scholarly literature on REIT specialisation value specifically in the Asia-Pacific region. Unlike previous studies that ignore the fact that various property sectors may characterise distinct market cycles, this research aims to demonstrate the REIT specialisation value by comparing different property types of REITs with diversified REITs from multi-dimensional investment perspectives – both investment performance and risk management dimensions.

The conceptual framework of this study aims to compare risk-adjusted returns; portfolio diversification benefits; risk-adjusted performance comparisons; roles in mixed-asset portfolios at domestic, regional and international levels; and interest rate sensitivity of Asia-Pacific sector-specific REITs versus diversified REITs. Additionally, the portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of different property types (e.g. office, retail, industrial, residential and specialty sectors) of regional REIT-based portfolios in the Asia-Pacific are assessed for the first time. To reinforce the REIT specialisation value in the Asia-Pacific region, these analyses will be extended to the US REIT market. The rigorous analyses undertaken in this study validate the existence of REIT specialisation value across the Asia-Pacific region and the USA.

Overall, the findings suggest that institutional investors should actively make their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio with multiple property sectors. The findings also validated the investment distinctions of REITs across different property sectors and various markets, including Japan, Australia, Singapore and the USA. This also highlights the importance of a dedicated study of each REIT sub-sector in different REIT markets, providing an insightful understanding of sector-specific REITs in the Asia-Pacific region and the USA.

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ABSTRACT

Asia-Pacific Real Estate Investment Trusts (REITs) have become a significant listed property sector in the international property investment space. One of the prominent attributes of Asia-Pacific REITs is that sector-specific REITs have played a prevailing role in the Asia-Pacific REIT markets compared with diversified REITs. This unique trajectory of sector-specific REITs aligns with the discussion of specialisation value in the finance literature. However, there is a paucity of scholarly literature on REIT specialisation value specifically in the Asia-Pacific region. Unlike previous studies that ignore the fact that various property sectors may characterise distinct market cycles, this research aims to demonstrate the REIT specialisation value by comparing different property types of REITs with diversified REITs from multi-dimensional investment perspectives – both investment performance and risk management dimensions.

The research objectives of this study aim to compare risk-adjusted returns; portfolio diversification benefits; risk-adjusted performance comparisons; roles in mixed-asset portfolios at domestic, regional and international levels; and interest rate sensitivity of Asia-Pacific sector-specific REITs versus diversified REITs. Additionally, the portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of different property types (e.g. office, retail, industrial, residential and specialty sectors) of regional REIT-based portfolios in the Asia-Pacific are assessed for the first time. To reinforce the REIT specialisation value in the Asia-Pacific region, these analyses will be extended to the US REIT market. The rigorous analyses undertaken in this study validate the existence of REIT specialisation value across the Asia-Pacific region and the USA.

Overall, the findings suggest that institutional investors should actively make their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio with multiple property sectors. The findings also validated the investment distinctions of REITs across different property sectors and various markets, including Japan, Australia, Singapore and the USA. This also highlights the importance of a dedicated study of each REIT sub-sector in different REIT markets, providing an insightful understanding of sector-specific REITs in the Asia-Pacific region and the USA.

ACKNOWLEDGEMENTS

This research would not have been possible without the support and guidance of the following people.

First and foremost, I express my tremendous gratitude to my principal supervisor, Associate Professor Chyi Lin Lee. His supervision has offered inspirational guidance, continual support, encouragement, understanding, patience and belief throughout my doctoral candidature. I would also like to thank my co-supervisor, Professor Graeme Newell, for his valuable suggestions and constructive advice in shaping the study and ensuring academic rigour in my research agenda. Both have actively supported the writing and publication of a variety of journal articles, which set a strong basis for the arguments and findings in this thesis.

I would like to express my special appreciation to Dr Jufri Marzuki, who as my mentor and friend has shared his invaluable experience with me in the always-challenging doctoral journey. My appreciation also goes to Dr Henry Chin, Assistant Professor Hsu-Wen Peng and Associate Professor Shun-Te Yuo. Both encouraged me to start the doctoral programme in Australia. I would also like to express my gratitude to Associate Professor Jin-Tsong Wang and Sheng-Jie Luo for solving my econometric software inquires, as well as Drs Alex Pham and Hyunbum Cho for sharing their invaluable industry experience with me.

I would like to acknowledge the contribution of my Annual Progress Review Panel, comprising Drs Brian Lee and Bee Oo, both of whom raised important questions and offered constructive suggestions to solidify my doctoral research plan. I am grateful to the FBE PhD cohort group members, Associate Professor Riza Yosia Sunindijo and Dr Paola Favaro. I also acknowledge the support of the UNSW International Postgraduate Award (UIPA), including a tuition fee waiver and a stipend. I hope to have returned the marvellous contribution provided by UNSW. I sincerely acknowledge the support of Real Capital Analytics, National Association of Real Estate Investment Trusts and Thomson Reuters Eikon for providing property performance and transaction data; this thesis would not be possible without their support.

Lastly, I owe a loving debt to both my parents, Su-Chao Tseng and Bing-Hui Lin, who have kept me free from family responsibilities and encouraged me to pursue and complete my PhD programme at a global top-50 university. There are no words to describe my deepest gratitude to my loving fiancée, who has been faithfully supportive, encouraging and understanding during the entire course of my doctoral programme.

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LIST OF ABBREVIATIONS

$	US Dollar
ACF	Autocorrelation Function
ACWI	All Countries World Index
ADF	Augmented Dickey-Fuller
ANREV	Asian Association for Investors
AP	Asia-Pacific
APREA	Asia-Pacific Real Estate Association
APT	Arbitrage Pricing Theory
ARCH	Autoregressive Conditional Heteroskedasticity
ARCH-M	Autoregressive Conditional Heteroskedasticity in Mean
A-REITs	Australian Real Estate Investment Trusts
ARES	Association of Real Estate Securitization
ASX	Australian Stock Exchange
AU	Australia
AXA	AXA S.A.
B	Billion
CAPM	Capital Asset Pricing Model
CBD	Central Business District
CBRE	Coldwell Banker Richard Ellis
CIA	Central Intelligence Agency
CIC	China Investment Corporation
CPPIB	Canada Pension Plan Investment Board
CRES	Commingled Real Estate Funds
DCF	Discounted Cash Flow
DJGL	Dow Jones Global Index
EPF	Employees Provident Fund
EPRA	European Public Real Estate
EU	Europe
FTSE	Financial Times Stock Exchange Association
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
GARCH-M	Generalised Autoregressive Conditional Heteroskedasticity in Mean
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GIC	Government of Singapore Investment Corporation
GICS	Global Industry Classification
H	Hypothesis
HK	Hong Kong
HKMA	Hong Kong Monetary Authority

HK-REITs	Hong Kong Real Estate Investment Trusts
HPT	Hypothetical Property Trusts
I&L REITs	Industrial and Logistics Real Estate Investment Trusts
I&P RE	I&P Real Estate
IFC	International Financial Centre
INREV	European Association for Investors in Non-Listed Real Estate Vehicle
IR	Interest Rate
IR 10y	10-Year IR
IR 3m	3-Month IR
JLL	Jones Lang LaSalle
JP	Japan
J-REITs	Japan Real Estate Investment Trusts
KIC	Korea Investment Corporation
K-REITs	South Korea Real Estate Investment Trusts
M	Million
MATLAB	Matrix Laboratory
MEA	Middle East and Africa
MPT	Modern Portfolio Theory
M-REITs	Malaysian Real Estate Investment Trusts
MSCI	Morgan Stanley Capital International
NAREIT	National Association of Real Investment Trusts
NCREIF	National Council of Real Estate Investment Fiduciaries
NPS	National Pension Service
NSW	New South Wales
NZ-REITs	New Zealand Real Estate Investment Trusts
PCA	Property Council of Australia
PREI	Prudential Real Estate Investors
PSFs	Property Securities Funds
PWC	Price Waterhouse and Coopers & Lybrand
QE	Quantitative Easing
r	Correlation Coefficient
RCA	Real Capital Analytics
REITs	Real Estate Investment Trusts
REITs-D	Daily REIT Index
REITs-M	Monthly REIT Index
REMD	Real Estate Management Company
REMFs	Real Estate Mutual Funds
REOC	Real Estate Operating Companies
RQ	Research Question
S&P	Standard & Poor's

SD	Standard Deviation
SP	Singapore
S-REITs	Singapore Real Estate Investment Trusts
SWF	Sovereign Wealth Fund
T	Trillion
Thai-REITs	Thailand Real Estate Investment Trusts
TR	Total Return
T-REITs	Taiwan Real Estate Investment Trusts
TRI	Total Return Index
UK	United Kingdom
UPF	Unlisted Property Funds
US	United States (adjective)
USA	United States of America
US-REITs	United Stated Real Estate Investment Trusts
VBA	Visual Basic Applications
YCL/UNSW	Yu-Cheng Lin/University of New South Wales
YOY	Year-on-Year

EXECUTIVE SUMMARY

Asia-Pacific REITs are a well-established listed property investment channel in the Asia-Pacific and international property investment space. One of the important attributes of Asia-Pacific REITs is that sector-specific REITs have played a prevailing role in the Asia-Pacific REIT markets compared with diversified REITs. According to the dataset constructed for this research, the average ratio of sector-specific REITs to composite REITs by market capitalisation has been 78.2% in the Asia-Pacific over the last 12 years. At a country level, the average ratio was 75.2% in Japan, 74.1% in Australia and 91.9% in Singapore. The unique trajectory of sector-specific REITs, also witnessed in the USA and Europe, can be attributed to the assertion of specialisation value, as discussed in the finance literature. However, there is a paucity of scholarly literature on REIT specialisation value in the Asia-Pacific region. Unlike previous studies, which by taking different property types of REITs as a hybrid specialised REIT have ignored the fact that various property sectors may have distinct market cycles, this research aims to demonstrate the REIT specialisation value by comparing different property types of REITs with diversified REITs from multi-dimensional investment perspectives – both investment performance and risk management dimensions.

This study assesses risk-adjusted returns; portfolio diversification benefits; risk-adjusted performance comparisons; roles in mixed-asset portfolios at domestic, regional and international levels; and interest rate sensitivity of Asia-Pacific sector-specific REITs from July 2006 to December 2018. The rigorously empirical analyses cover six REIT sub-sectors (office, retail, industrial, residential, specialty and diversified REITs) across three domestic markets in the Asia-Pacific (Japan, Australia and Singapore), as well as in the regional and global contexts. Four methodological clusters used in this study are: (1) performance analysis (risk-adjusted performance, portfolio diversification and risk-adjusted performance comparison analyses); (2) portfolio analysis (optimal and constrained mean-variance portfolio frameworks); (3) interest rate sensitivity analysis (the GARCH-M specification) and (4) sub-period analysis. These analyses will be extended to assess the REIT specialisation value in the USA as the validation of this thesis. These four analyses provide the structure of the analysis in this research.

The risk-adjusted performance results indicate that different property types of REITs offer superior risk-adjusted returns to diversified REITs in domestic, regional and global contexts. Importantly, the comparison results exhibit a clear distinction between different property types of REITs and their diversified counterparts on a risk-adjusted return basis. This implies that different property types of REITs are distinct risk-adjusted investment assets from diversified REITs across these four markets. In terms of portfolio diversification potential, sector-specific REITs delivered stronger diversification benefits with domestic stocks and comparable diversification benefits with domestic bonds compared with their diversified counterparts across these four markets. In the international context, sector-specific REITs delivered more attractive geographic diversifications with US- and EU-REITs compared with diversified REITs. In terms of an inter-property investment strategy, a sectoral REIT investment strategy provided stronger portfolio diversification benefits than an inter-REIT investment strategy in domestic, regional and global contexts. Specifically, a regional sectoral REIT investment strategy could offer 6% more effective diversification benefits for investors compared with a regional inter-REIT investment strategy. The diversity of sector-specific REITs can translate directly into improved sectoral diversifications for investors seeking portfolio diversifying in these four domestic markets, and in the Asia-Pacific region. The above findings suggest that institutional investors seeking listed property exposure in the Asia-Pacific region and the USA should actively make their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than passively relying on a diversified REIT with multiple property sectors.

The prominent role of sector-specific REITs was observed in mixed-asset portfolios across Japan (57.9%), Australia (40.2%) and Singapore (38.4%), as well as in the regional (74.2%) and international contexts (53.1%) over the full study period. However, diversified REITs rarely found roles in multi-asset portfolios in domestic, regional and global contexts. In addition, the portfolio allocations of sector-specific REITs were found across the entire risk-return spectrum. This suggests that sector-specific REITs are an investment asset for both risk-averse and risk-taking investors. Compared with stocks and bonds, sector-specific REITs have been seen as high-risk investment assets, since most of their portfolio configurations are embedded in the higher end of the risk-return scale. This makes sector-specific REITs a compelling investment asset, co-existing alongside mainstream asset classes in institutional investor portfolios in domestic, regional and global contexts. Importantly, these findings empirically validate the existence of REIT specialisation value in the Asia-Pacific region and the USA over the last 12 years. This implies that institutional investors seeking listed property exposure in these regions should consider including different property types of REITs, rather than their diversified counterparts, in their local, regional and international portfolios. The strong investment performance of different property types of REITs indicates that sector-specific REITs are a favourable REIT structure for meeting institutional investor appetite, reflecting the prominent player of various property types of REITs in the Asia-Pacific region and the USA over the last 12 years. REIT investment advisors should suggest sector-specific REITs to clients who are willing to establish a new REITs in Japan, Australia, Singapore and the USA, as well as in the Asia-Pacific region more broadly.

Different property types of regional REIT-based portfolios constructed in this research have offered a practical context for the mandatory schemes by international property funds gaining exposure to regional REIT-based portfolios. These portfolios include regional office, retail, industrial, residential and specialty REIT-based portfolios in the Asia-Pacific, comprising cross-country sector-specific REITs across Japan, Australia, Singapore and the USA. The empirical findings regarding portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of five different property types of regional REIT-based portfolios provide comprehensive insights into how they structure their REIT portfolios under these mandates, as well as geographic and sectoral diversification strategies.

The econometric analysis of the interest rate sensitivity of sector-specific REITs in domestic contexts across Japan, Australia, Singapore and the USA finds that diversified REITs was more susceptible to interest rate changes compared with sector-specific REITs. This can be attributed to a diversified REIT portfolio covering different property sectors. In short, insignificant exposure to interest rate risk of sector-specific REITs may imply that sector-specific REITs have a stronger interest rate risk aversion and hedging actions than their diversified counterparts. Importantly, this validates the existence of REIT specialisation value in the Asia-Pacific region and the USA from the interest rate risk management perspective. Of sector-specific REITs, retail and residential REITs were vulnerable to interest rate movements, while industrial REITs was only sensitive to interest rate fluctuations prior to the GFC. However, office and specialty REITs were generally immune to interest rate changes. This may be attributed to the distinct lease structures of different types of property sectors, since the term structure of property leases can be substantially impacted by the interest rate risk (Ambrose and Yildirim, 2008; Agarwal *et al.*, 2011). The interest rate sensitivity findings are particularly valuable to international property investors constructing and managing portfolios with REITs in the region so as to reduce or hedge interest rate risk exposure. Additionally, property investors are advised to be aware of the time-varying disparities in the magnitude and direction of the sensitivity to interest rate level and volatility of different property types of REITs across these four markets, in order to cater to the dynamic interest rate risk management of each property type of REITs in local, regional and international investment portfolios.

These findings clearly illustrate that risk-return attributes of sector-specific REITs are distinct across different types of property sectors and across these four markets. This reflects the fact that each property sector has a unique different market cycle, as well as the investment distinctions between different markets. This highlights the significance of a dedicated study of each REIT sub-sector in different REIT markets, in order to provide insights into sector-specific REITs in the Asia-Pacific region and the USA.

Both theoretical and practical contributions have been made in this research. The theoretical contributions of this research expand on the existing body of literature on REITs by equipping international scholars, practitioners and policymakers with comprehensive insights into dynamic risk-return attributes of different property types of REITs. The main practical contribution extends the current knowledge of REITs to the under-researched sector-specific REITs as effective and liquid listed property investment exposure in the Asia-Pacific region and the USA, as well as an increasingly institutionalised property sector going forward. The findings of this research can be expected to enable international property investors, such as insurers, pension funds, sovereign wealth funds, Real Estate Mutual Funds (REMFs)/Property Securities Funds (PSFs; exclusively used in Australia)/REIT Funds and income-oriented investors, to make well-informed and strategic decisions regarding different property types of REITs across Japan, Australia, Singapore and the USA, as well as in the Asia-Pacific region more broadly.

LIST OF PUBLICATIONS

The results reported in this thesis have been externally validated by four publications in leading property research journals in the UK and Australia, as well as conference papers, as follows.

Journal articles:

1. Lin, Y. C., Cho, H. and Lee, C. L. (2019). The value-added role of sector-specific REITs in Australia. *Pacific Rim Property Research Journal*, *25*(1), 49-72.
2. Lin, Y. C., Lee, C. L. and Newell, G. (2019). The significance of residential REITs in Japan as an institutionalised property sector. *Journal of Property Investment & Finance*, *37*(4), 363-379.
3. Lin, Y. C., Lee, C. L. and Newell, G. (2020). The added-value role of industrial and logistics REITs in the Pacific Rim region. *Journal of Property Investment & Finance*, *38*(6), 597-616.
4. Lin, Y. C., Lee, C. L. and Newell, G. (2021). Varying interest rate sensitivity of different property sectors: cross-country evidence from REITs. *Journal of Property Investment & Finance* (in revision).

Conference papers:

1. Lin, Y. C., Lee, C. L. and Newell, G. (2019). The Value-added Role of Sector-Specific A-REITs. *Pacific Rim Real Estate Society Conference (PRRES)*, 14-16 January, Melbourne, Australia.
2. Lin, Y. C., Lee, C. L. and Newell, G. (2019). The Significance of Residential REITs in Japan as an Institutionalised Property Sector. *European Real Estate Society Conference (ERES)*, 3-6 July, Paris, France.
3. Lin, Y. C., Lee, C. L. and Newell, G. (2019). The Significance of Logistics REITs an Institutionalized Property Sector. *European Real Estate Society Conference (ERES): EPRA Session*, 3-6 July, Paris, France.
4. Lin, Y. C., Lee, C. L. and Newell, G. (2020). The Value-added Role of Sector-specific A-REITs. *Pacific Rim Real Estate Society Conference (PRRES)*, 19-22 January, Melbourne, Australia.
5. Lin, Y. C., Lee, C. L. and Newell, G. (2020). The Value-added Role of Industrial and Logistics REITs in the Pacific Rim Region. *American Real Estate Society Conference (ARES)*, Florida, USA (accepted; conference cancelled due to COVID19).
6. Lin, Y. C., Lee, C. L. and Newell, G. (2021). Varying interest rate sensitivity of different property sectors: cross-country evidence from REITs. *American Real Estate Society Conference (ARES)*, Virtual conference.

CHAPTER 1
INTRODUCTION

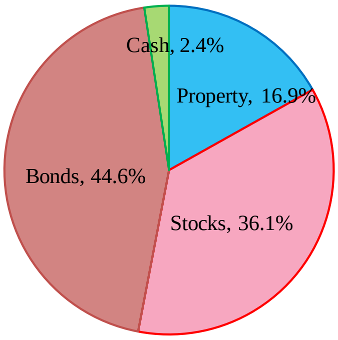
Chapter 1 introduces Asia-Pacific sector-specific Real Estate Investment Trusts (REITs) as an investment asset class and investment vehicle for investors to gain property exposure globally. A brief presentation of the current trends in Asia-Pacific sector-specific REITs and detailed elaboration of the international scholarly literature on sector-specific REITs are provided. This elucidates the importance of assessing the investment performance of Asia-Pacific sector-specific REITs, and the lack of research placing on multi-dimensional investment aspects, which is a primary motivation for this study. The chapter illustrates the research gaps, research questions, objectives, dataset, methodologies and contributions of this study.

1.1 BACKGROUND

Property has played an increasingly important role in the global investment space in recent years. The total assets of the international investable property market were estimated to be US$35.5 trillion in 2016 – representing 36% of the market capitalisation of the global economy – and this is expected to grow to US$59.2 trillion by 2026 and US$101.5 trillion by 2036 (PREI, 2017a). **Figure 1-1** shows that property was the third-largest asset class in 2019, accounting for 16.9% of investable asset classes in the USA, exceeded only by stocks (36.1%) and bonds (44.6%) and surpassing cash (2.4%). Property has become a substantial investment asset in the international investment space (PREI, 2017b; CBRE, 2018c; NAREIT, 2019).

With unique investment features that are fundamentally distinct from stocks, bonds and cash, property has been seen as one of the four permanent mainstream investment asset classes by both institutional and retail investors in the international context (Geltner *et al*., 2014). Property tends to move in different cycles from the other major asset classes, with a multitude of investment vehicles and a broad range of property sectors, such as office, retail, industrial and residential properties (Giliberto, 1992). These unique investment features result in property being an essential element of the multi-asset investment portfolios by potentially characterising distinct investment performance profiles, offering portfolio diversification benefits and decreasing portfolio risk, as well as enhancing portfolio returns for investors in the international context. Furthermore, income stability, capital growth, tax reduction and effective hedging against inflationary pressure are other critical investment benefits of the property markets (Hartzell, 1986; Baum and Hartzell 2012).

Figure 1-1: Significance of property in the US investment space: 2019



Source: Author's compilation from NAREIT (2019)

In general, there are two categories of property assets: commercial and residential properties. Commercial property is mainly possessed by large-scale institutional investors, while residential property is mostly owned by individual and small investors. Global commercial property transactions contributed over US$1.7 trillion in 2018 (RCA, 2018b). This comprised a broad range of property investors, such as REITs, non-listed property funds, private equity funds, insurance companies, pension funds, sovereign wealth funds and high-wealth individuals, who utilised a broad range of different property investment vehicles, such as direct property, separate accounts, joint ventures, club deals and non-listed real estate funds (RCA, 2018b).

The wide range of property investment channels for property investors can be categorised into two primary property investment vehicles: direct property and indirect property (Baum and Hartzell 2012). Direct property investment refers to investors possessing and controlling the physical property. This form of investment is a capital-intensive activity and requires a wide range of active and specialist property management skills. This limits the threshold to investors with large amounts of capitals (institutional investors) in a private marketplace (Geltner *et al*., 2014).

On the other hand, indirect property investment refers to investors seeking an indirect route to gain property exposure via possessing fractional ownership of the underlying property in the form of a fund (Unlisted Property Funds (UPFs), Real Estate Mutual Funds (REMFs)) or a stock (Real Estate Investment Trusts (REITs)) that manages a portfolio of a broad range of property sectors (Yavas and Yildirim, 2011; Hoesli and Oikarinen, 2012; Hoesli *et al*., 2015; Lee, 2018; Lin *et al.*, 2019a, b, 2020). Compared with the direct property investment, investors seeking indirect property investment are, in most cases, not burdened with high levels of capitals and property management requirements, but can benefit from both sectoral and geographical diversifications since property assets are from various sectors and locations (Fisher and Liang, 2000; Glascock *et al.*, 2000; Newell and Tan, 2003; Ling and Naranjo, 2015; Delfim and Hoesli, 2019).

Within indirect property investment vehicles, REITs are functionally and strategically different from Real Estate Operating Companies (REOCs). According to the Global Industry Classification Standard (GICS), a REIT is a listed company that owns and manages a portfolio of high-quality income-producing commercial properties. Despite being listed on the stock market and publicly traded, REITs offer a strong and stable income stream coming from leasing space and collecting rent from tenants on commercial property leases (Newell, 2012). The structure of REITs has three critical features: (1) the transfer of management burden; (2) tax transparency; and (3) distribution requirements, making REITs a yield-oriented property exposure compared with listed property companies (EPRA, 2018a). With the added benefits of liquidity, transparency and fiscal efficiency, REITs have to pay out at least 90% of their taxable income to their investors (PWC, 2011). These have seen REITs owning and managing portfolios with commercial properties as the underlying assets to secure their income streams and deliver attractive yields. On the other hand, REOCs fund new constructions and deal in property acquisitions as investment returns, only allowing investors to buy shares of the firm and reinvest in new projects (Baum and Hartzell 2012).

REITs are expected to reflect the investment performance of direct property in the long term, validated as a close substitute for direct property in mixed-asset portfolios with the added benefits of greater liquidity, higher transparency, substantial and stable dividend yields, lower transaction costs, lesser performance and cost management, and the existence of public markets for property securities (Glascock *et al*., 2000; Pagliari *et al*., 2005; Hoesli and Moreno, 2006; Horrigan *et al*., 2009; Pavlov and Wachter, 2010; Hoesli and Oikarinen, 2016; Cotter and Roll, 2015; Hoesli *et al*., 2015; Ling and Naranjo, 2015; Delfim and Hoesli, 2019). Therefore, REITs have become increasingly institutionalised in recent years (Stansell and Coffin, 2000; Ciochetti *et al*., 2002; Ghosh and Sirmans, 2003; Chan *et al*., 2005; Hartzell *et al*., 2006; Feng *et al*., 2010, 2011; Chung *et al*., 2012; Devos *et al*., 2013; Aguilar *et al*., 2018; Ling *et al*., 2019; NAREIT, 2019). Institutional ownership as a proportion of total ownership in REITs soared from 14.14% in 1990 to 75.19% in 2011 (An *et al*., 2016). In the Asia-Pacific context, the J-REIT market comprises a wide range of property investors, including financial institutions (55.6% of J-REIT holdings), securities companies (9.2%), business corporations (25.0%) and foreigners (8.5%) (ARES, 2016a). In Japan, 66% of institutional investors invest in J-REITs, and 14% of Japan pension funds include J-REITs in their mixed-asset portfolios (ARES, 2016b). **Table 1-1** lists major property investors in the Asia-Pacific, including insurers (e.g. Ping An Insurance, AXA), pension funds (e.g. NPS, EPF) and sovereign wealth funds (e.g. CIC, HKMA, GIC).

Recent years have seen REITs emerge as a significant property investment vehicle in the global property investment market. Over 51.4% of the total assets of the global listed property market was contributed by REITs in 2018 (EPRA, 2018c). As depicted in **Figure 1-2**, Asia-Pacific REITs represented an average of 22.8% of the global REIT market from July 2006 to December 2018, with 245 REITs and a market capitalisation of US$327.8 billion in December, up from US$124.1 billion in July 2006, a 2.6-fold increase over the last 12 years. The strong growth in market capitalisation of the Asia-Pacific REIT markets has been associated with the increasing significance of the Asia-Pacific property markets in the international property investment space, with strong economic outputs, high population demographics and urbanisation, and increasing levels of liquidity (CBRE, 2018a, b; CIA, 2018; EPRA, 2018c; JLL, 2018). Considerable economic growth has been seen in the Asia-Pacific across both developed markets (e.g. Japan, Australia, Singapore, Hong Kong) and developing markets (e.g. China, India, Indonesia) in recent years (EPRA, 2018c). In addition, the Asia-Pacific has had strong population growth across China and India, and high urbanisation in major international cities in the region, including Beijing, Shanghai, Shenzhen, Tokyo, Osaka, Sydney, Hong Kong and Singapore (CIA, 2018). Improved property market transparency has also been seen across Japan, Taiwan, China, India and South Korea, enhancing property investor confidence in the region (JLL, 2018).

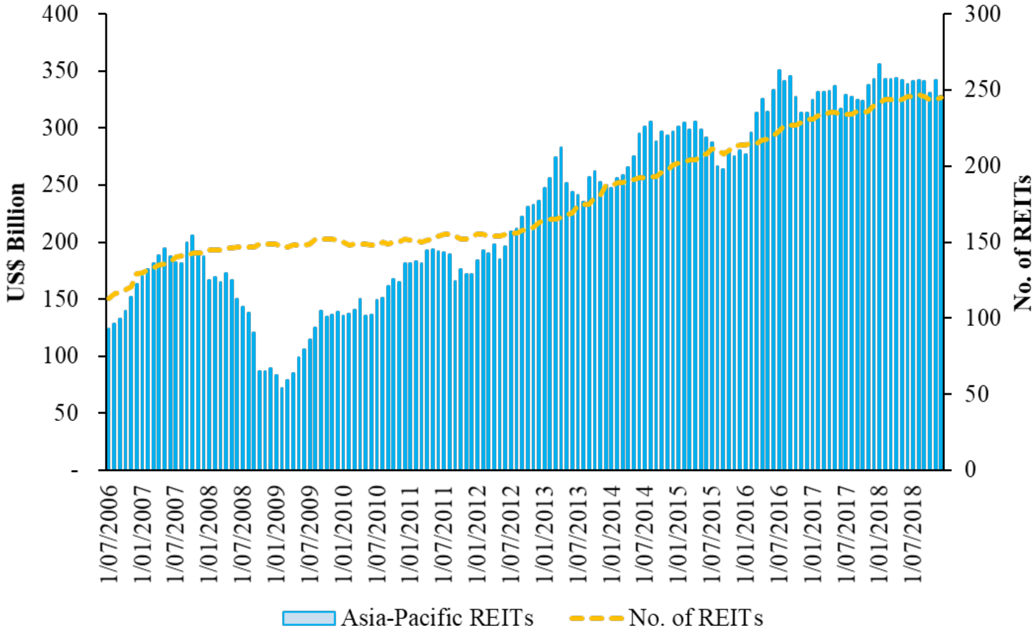
Importantly, the Asia-Pacific has been seen as a global economic recovery engine from the GFC, isolated from the economic uncertainty in the USA and sovereign debt issues in Europe (Newell, 2012). These have seen Asia-Pacific REITs emerge as a significant regional REIT market in the international context. With the increasing institutional investor appetite for REITs as a liquid listed property investment exposure, an increased institutional involvement in the Asia-Pacific REIT investment space is expected to be seen going forward.

Table 1-1: Major property investors in the Asia-Pacific: 2018

Insurers:
Ping An Insurance: China; US$1,038.5 billion (No. 1 globally)
AXA: France; US$912.0 billion (No. 2)
Allianz: Germany; US$796.1 billion (No. 3)
Pension funds:
National Pension Service (NPS): South Korea; US$582.4 billion (No. 4 globally)
Canada Pension Plan Investment Board (CPPIB): Canada; US$268.5 billion (No. 8)
Employees Provident Fund (EPF): Malaysia; US$178.5 billion (No. 13)
Future Fund: Australia; US$102.3 billion (No. 29)
Sovereign wealth funds:
China Investment Corporation (CIC): China; US$813.5 billion (No. 2 globally)
Hong Kong Monetary Authority (HKMA): Hong Kong; US$466.6 billion (No. 6)
Government of Singapore Investment Corporation (GIC): Singapore; US$359.0 billion (No. 8)
Temasek: Singapore; US$197.1 billion (No. 13)
Korea Investment Corporation (KIC): South Korea; US$110.8 billion (No. 15)

Source: Authors' compilation from Forbes Global 2000 (2018); I&P RE (2018); Willis Towers Watson (2018); www. swfinstitute.com

Figure 1-2: Growth in market capitalisation for Asia-Pacific REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

1.1.1 Emergence of Sector-Specific REITs in the Asia-Pacific

One of the striking aspects of Asia-Pacific REITs is that sector-specific REITs played a major role in the Asia-Pacific REIT markets. According to the dataset constructed for this research, as of 2018 sector-specific REITs accounted for 78.2% of the total assets of Asia-Pacific REITs. The trend has also been observed in the USA (93%) and European REIT markets (72%) (NAREIT, 2018). Over the last 12 years, the average ratio of sector-specific REITs to composite REITs by market capitalisation has been 75.2% in Japan, 74.1% in Australia, 91.9% in Singapore, 83.5% in Hong Kong, 93.6% in Thailand, 85.6% in Malaysia and 97.3% in South Korea, as reported in the dataset for this study. Sector-specific REITs have played a prevailing role in the Asia-Pacific REIT markets compared to their diversified counterparts.

The strong growth of sector-specific REITs is consistent with the increasing investment appetite, particularly among sophisticated institutional investors who are willing to actively make their own sectoral diversification decisions, rather than passively leaving these decisions to diversified players (Fisher and Liang, 2000; Lee, 2001; Newell and Tan, 2003; Chen, 2007; Case *et al.*, 2010; Leone and Ravishankar, 2018). **Table 1-2** lists the benefits of investment in sector-specific REITs from the aspect of diversification benefits, management efficiency and market information transparency. Management expertise can be more effective when a REIT is specialised by property type (Capozza and Seguin; 1999; Nanda and Narayanan, 1999; Geltner *et al*., 2014). The preference for sector-specific REITs can be elucidated by the effect of firm specialisation proposition in the finance literature. This posits that one business segment trades at a premium compared to their multiple counterparts (Hyland and Diltz, 2002; Villalonga, 2004). In the Asia-Pacific REIT context, players in sector-specific REITs include Link REIT (HK; retail sector; US$21.4B), Scentre Group (Australia; retail sector; US$14.6B); Goodman (Australia; industrial sector; US$13.6B); Nippon Building Fund (Japan; office sector; US$8.9B) and Capitaland Mall Trust (Singapore; retail sector; US$6.1B). On the other side, players in diversified REITs include GPT Group (Australia; US$6.8B) and Stockland (Australia; US$6.0B). The unique market phenomenon reflects the potential for more substantial investment performance, higher portfolio diversification benefits, and added-value roles in the multi-asset portfolios for sector-specific REITs as a preferable REIT structure to satisfy institutional investor appetite.

Table 1-2: Benefits of investment in sector-specific REITs

(1)	**Diversification benefits:**
	Active diversification decisions
	Increased level of sectoral diversifications since the early 1990s
(2)	**Management efficiency:**
	Lower borrowing costs
	Lower expense costs
	Specialised management expertise
(3)	**Transparent market information:**
	Efficiency in the valuation in the individual property firm
	Lower level of information asymmetries
	Higher level of liquidity

Source: Authors' compilation from Capozza and Seguin (1999); Nanda and Narayanan (1999); Eichholtz *et al.* (2000); Danielsen and Harrison (2007); Geltner *et al.* (2014); Chong *et al.* (2012)

Despite specialisation emerging as the preferable REIT structure (compared with diversified REITs) for investors, it is unclear whether sector-specific REITs offer heightened risk-adjusted returns, enhanced portfolio diversification benefits and increased portfolio returns. The consensus on the firm specialisation assertion in REITs had yet to be reached in the US context prior to the GFC (Eichholtz *et al*., 2000; Benefield *et al*., 2009; Ro and Ziobrowski, 2011). Given an adverse impact of the GFC upon the international REIT market (Kim, 2009; Newell and Razali, 2009; Peng and Lee, 2013; Lee *et al*., 2016), it is imperative to offer updated empirical evidence on REIT specialisation value after the GFC.

The validation of diversifications by property type as an effective portfolio investment strategy for institutional investors also implies that property sectors are segmented and possess divergent risk-return characteristics. The property segmentation issue has significant investment implications for institutional investors seeking portfolio diversifications. If various property markets are segmented, these markets will move to distinct directions over the long run, with enhanced diversification benefits for investors (Cheng and Glascock, 2005; Gerlach *et al*., 2006; Liow, 2008). In contrast, if different property markets are integrated, these markets will travel in the similar direction over the long run, with limited diversification benefits (Garvey *et al*., 2001; Wilson and Zurbruegg, 2003a; Yang *et al*., 2005). The property segmentation issue can be attributed to the fact that different property sectors may have various market fundamentals, such as asset durability, investment lags, supply or demand elasticities, lease structures and the uses of credit to finance development (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a). The attractiveness for practitioners and scholars has concentrated on composite REITs, while few studies have focused on individual REIT sub-sectors. This is despite the fact that numerous studies have acknowledged the existence of the sectoral effect, in which various property sectors feature distinct market cycles. At a single sector level, no comparable study has demonstrated differences between different property types of REITs and diversified REITs in terms of risk-return attributes, with respect to the REIT specialisation value asserted in the property and finance literature.

Since the GFC in 2008, a loose monetary policy (Quantitative Easing, QE) has been employed to stimulate the global economy, by lowering interest rates to historically low levels to relieve borrowing costs and accelerate market deals (Volker, 2009; Claeys and Leandro, 2016). Practitioners and scholars have discussed how property markets will behave in response to future rises in interest rates (Devaney, 2001; Liow and Huang, 2006; Bredin *et al*., 2007; Stevenson *et al*., 2007; Lee *et al*., 2014; CBRE, 2018b; RCA, 2018b; Reddy and Wong, 2018). However, no comparable study has been devoted to the issue at a single REIT sub-sector level, given the reality that lease length varies across property types, substantially influenced by the interest rate risk (Clapham and Gunnelin, 2003; Grenadier, 2005; Crosby *et al*., 2006; Ambrose and Yildirim, 2008; Agarwal *et al*., 2011).

Overall, composite REITs have been validated as a close substitute for direct property in mixed-asset portfolios with the added benefits of liquidity, transparency, fiscal efficiency, professional property management, and stable and long-term income streams. Given that the important role of sector-specific REITs has been the prevailing trend in the international REIT market, rigorous research on comparing different property types of REITs with diversified REITs on multi-dimensional investment aspects of the investment performance, portfolio diversification benefits, roles in mixed-asset portfolios and interest rate sensitivity is expected to enable REIT investors, particularly REMFs/PSFs (e.g. Vanguard, Invesco, UBS, LaSalle) and income-oriented investors, to make more informed and practical investment decisions regarding sector-specific REITs in the Asia-Pacific region. The findings offer a comprehensive view of custom-designed balanced portfolios, investment performance, portfolio diversifications and interest rate risk management strategies regarding different property types of REITs at domestic, regional and international levels to property portfolio managers and policymakers who gain listed property exposure in the Asia-Pacific region.

1.2 RESEARCH GAPS

While the prominent role of sector-specific REITs seen in the international REIT market in recent years, the investment benefits of the REIT specialisation value have not been thoroughly examined in the international context, particularly in the Asia-Pacific region. The assertion of specialisation value in the finance literature posits that a single-business segment trades at a premium over their diversified counterparts (Delong, 2001; Hyland and Diltz, 2002; Yao *et al*., 2004). Some REIT scholars have discovered some evidence against the assertion of REIT specialisation value (Benefield *et al*., 2009; Ro and Ziobrowski, 2011). However, a REIT specialised by property type was documented as being more effective regarding management expertise by other REIT scholars (Danielsen and Harrison, 2007; Chong *et al*., 2012). These studies mainly focus on US-REITs, and no international study is available to validate the REIT specialisation value.

This study – by taking different property types of REITs as a hybrid specialised REIT that ignores the fact that various property sectors may characterise distinct market cycles (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Chong *et al*., 2012; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Lin *et al*., 2019a) – is the first to demonstrate the REIT specialisation assertion by comparing different property types of REITs with diversified REITs from the investment performance and interest rate risk management perspectives. Since the global REIT market has been influenced by the GFC, it is imperative to offer a rigorous analysis of the assertion of REIT specialisation value in the post-GFC context. By doing so, this thesis addresses a central research gap in the body of knowledge on this topic.

Secondly, the strong linkage between REITs and direct property has been documented in numerous studies (Glascock *et al*., 2000; Clayton and MacKinnon, 2003; Pagliari *et al*., 2005; Riddiough *et al*., 2005; Chiang *et al*., 2006; Hoesli and Moreno, 2006; Li *et al*., 2009; Hoesli and Oikarinen, 2012, 2016; Yong and Pham; 2015; Delfim and Hoesli, 2019), implying that REITs could reflect the investment performance of direct property, with added benefits of greater liquidity, higher transparency, substantial and stable dividend yields, lower transaction costs, lesser performance and cost management, and the existence of public markets for property securities. The significance of composite REITs has attracted international scholarly interest in its investment, portfolio diversifications and roles in mixed-asset portfolio strategies in the USA (Fisher and Liang, 2000; Stevenson, 2002; Mueller and Mueller, 2003; Newell and Tan, 2003; Lee and Stevenson, 2005; Case *et al*., 2010), Europe (Kovac and Lee, 2008; Newell *et al*. 2013; Moss and Farrelly, 2015; Newell and Marzuki, 2016; Marzuki *et al*., 2020) and the Asia-Pacific (Yunus and Swanson, 2007; Dimovski, 2010; Ong *et al*., 2011; Liow, 2012; Newell and Peng, 2012; Reddy *et al*., 2014; Newell *et al*., 2015; Sing *et al*., 2016; Cho, 2017; Lee, 2018; Ooi *et al*., 2018; Liow *et al*., 2019a). However, few studies have focused on individual REIT sub-sectors. This is despite the fact that numerous studies have acknowledged that various property sectors feature characterise market cycles (Hamelink and Hoesli, 2004; Crosby *et al*., 2006; Yavas and Yildirim, 2011; Hoesli and Oikarinen, 2012; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a). Several studies have examined office (Newell *et al*., 2009), retail (Newell and Peng, 2007a), industrial (Lin *et al*., 2020), residential (Newell and Fischer, 2009; Lin *et al*., 2019b), storage (Bohjalian, 2018), lodging (Jackson, 2009) and other REITs (e.g. infrastructure REITs, data centre REITs) (Newell and Peng, 2008; Marzuki and Newell, 2019a). Unlike the sector-specific REIT literature assessing individual REIT sub-sectors only at an individual country level, this study conducts a comparative analysis of sector-specific REITs (office, retail, industrial, residential, specialty REITs) and diversified REITs in domestic, regional and global investment contexts. This is with respect to the REIT investment distinctions among different property sectors and across various markets, as well as the assertion of REIT specialisation assertion. Hence, this research is the first study to offer a rigorously empirical analysis of the investment performance, portfolio diversifications, roles in mixed-asset portfolios at domestic, regional and global levels for all property types of REITs across Japan, Australia and Singapore.

Thirdly, one could make a case that funds, particularly REMFs/PSFs, have a mandate to gain exposure to regional REIT-based portfolios, while international property investors would not build country-specific portfolios from a practical point of view. Importantly, a regional REIT-based portfolio offers a wide range of investment information, including speculation, implementation, custom-designed balanced portfolios, portfolio diversifications and historical performance indices of REIT sub-sectors (Geltner and Kluger, 1998). Therefore, this study empirically examines the investment performance and diversifications of five different property types of regional REIT-based portfolios at the regional aggregate level for the first time, reflecting the sectoral effect whereby different property sectors are characterised by distinct risk-return attributes. These regional REIT-based portfolios include Asia-Pacific office, retail, industrial, residential and specialty REIT-based portfolios.

Lastly, recent years have seen the continuation of the historically low-interest rate environment in the Asia-Pacific region. Future rises in interest rates have been seen as a critical risk factor for investors seeking property investment exposure in the international context (CBRE, 2018b; RCA, 2018b). This has raised questions among investors as to how REITs will respond to interest rate movements. The interest rate sensitivity of composite REITs has been widely documented by practitioners and scholars (Devaney, 2001; Liow and Huang, 2006; Bredin *et al*., 2007; Stevenson *et al*., 2007; Lee *et al*., 2014; Akimov *et al*., 2020). However, no comparable study has placed the issue at a single REIT sub-sector level. This is despite the fact that the sectoral effect and specialisation assertions have been broadly acknowledged. Therefore, this research will be the first analysis to gauge the interest rate sensitivity of REITs among different property sectors and across various markets in the Asia-Pacific region.

1.3 RESEARCH QUESTIONS

As discussed in the preceding sections, several research issues surrounding sector-specific REITs have not been addressed in the literature, as follows.

1. Do sector-specific REITs outperform diversified REITs in the Asia-Pacific region?

2. What roles do Asia-Pacific sector-specific REITs play in domestic mixed-asset portfolios compared with diversified REITs, stocks and bonds?

3. What are the optimum levels of Asia-Pacific-based sector-specific REITs in mixed-asset portfolios in both the regional and international contexts?

4. What are portfolio returns, risk, diversifications, and asset allocation implications of different property types of Asia-Pacific REIT-based portfolios?

5. Would Asia-Pacific sector-specific REITs response to changes in interest rates differently?

6. Would the REIT specialisation value in the Asia-Pacific exist in other REIT markets?

1.4 RESEARCH OBJECTIVES

This research aims to assess the performance and added-value and diversification benefits of Asia-Pacific sector-specific REITs in domestic, regional and global investment contexts from July 2006 to December 2018 (since specialty REITs in Singapore can only be tracked back to July 2006). **Figure 1-3** illustrates the coverage of this study, including domestic REIT markets in the Asia-Pacific across Japan, Australia and Singapore (light-blue blocks), as well as in the regional (dark-blue blocks) and global contexts, with validation against the US-REIT market (red blocks). These three markets have, on average, contributed 86.6% of the size of the Asia-Pacific REIT markets from July 2006 to December 2018. Additionally, the REIT sub-sector equities in other Asia-Pacific REIT markets are too thin to offer a comprehensive understanding of the existence of REIT specialisation value in the region. This study will examine five different property types of Asia-Pacific REIT-based portfolios, in order to reflect listed property investors with capital to mandate regional REIT-based portfolios from a practical point of view. Each property type of regional REIT-based portfolio comprises the corresponding sector-specific REITs in Japan, Australia and Singapore, benchmarked against that in the USA. These include Asia-Pacific office, retail, industrial, residential and specialty REIT-based portfolios. More importantly, this study will measure the interest rate sensitivity of Asia-Pacific sector-specific REITs at both the market and sector levels, including three REIT markets in the Asia-Pacific (Japan, Australia, Singapore) and six REIT sub-sectors (office, retail, industrial, residential, specialty and diversified REITs). To be able to address the research questions listed above, several research objectives have been identified.

1. To compare sector-specific REITs with diversified REITs in the Asia-Pacific region.

2. To examine the levels of asset allocation and diversification potential for sector-specific REITs in domestic mixed-asset portfolios compared with diversified REITs, stocks and bonds.

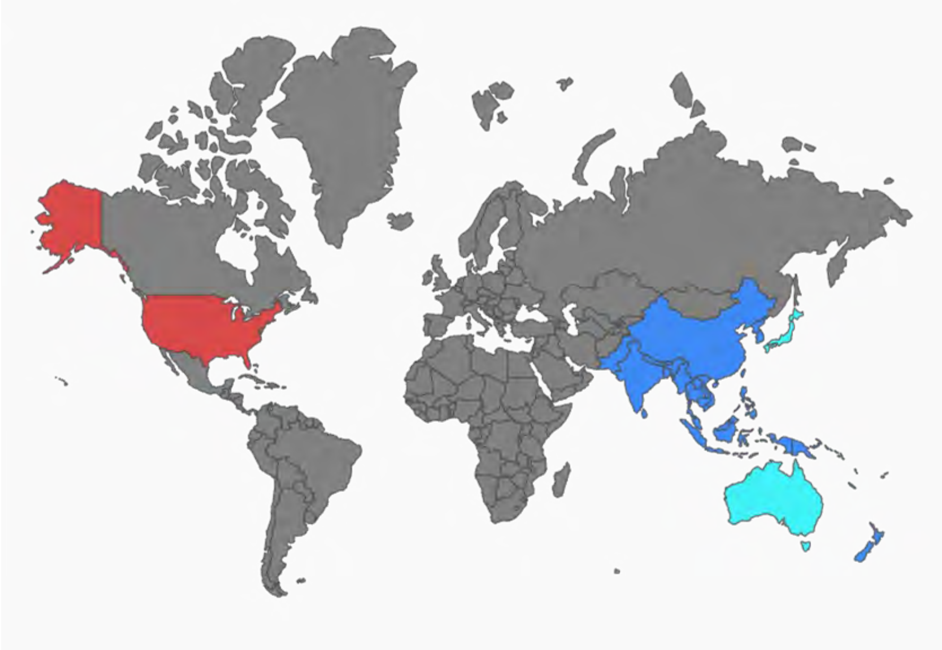
3. To determine the optimal portfolio allocations of Asia-Pacific-based sector-specific REITs in mixed-asset portfolios in both regional and international investment perspectives.

4. To demonstrate the returns, volatility and risk-adjusted return enhancement of different property types of Asia-Pacific REIT-based portfolios.

5. To assess the impact of interest rate changes on sector-specific REITs in the Asia-Pacific region.

6. To validate the notion of REIT specialisation value in the Asia-Pacific region.

Figure 1-3: Coverage of the thesis



Source: Author's compilation

1.5 RESEARCH METHODOLOGIES

Monthly total returns are assessed for domestic sector-specific REITs, diversified REITs, stocks and bonds across Japan, Australia and Singapore. The principal dataset for Asia-Pacific REIT sub-sectors categorised by the GICS was sourced from the market value-weighted free-float-adjusted REIT sub-sector indices across Japan, Australia and Singapore constructed for this study. The REIT sub-sector indices in the USA used were sourced from the FTSE/NAREIT/EPRA US REIT sub-sector total return series. Monthly total returns were estimated from July 2006 to December 2018 for sector-specific REITs, diversified REITs and the other mainstream asset classes across Japan, Australia and Singapore, since the availability of specialty REITs in Singapore can only be tracked back to July 2006. To achieve the abovementioned research objectives, this research includes four main methodological frameworks.

The first methodologic framework is designed to address RQ1 and RQ2, investigating the performance, portfolio diversification benefits, risk-adjusted performance comparisons and roles in domestic mixed-asset portfolios for sector-specific REITs compared with diversified REITs, stocks and bonds across Japan, Australia and Singapore. The Sharpe ratio was utilised to reflect the risk-adjusted performance of all asset classes. The correlation coefficient analysis was employed to present the portfolio diversification potential that can be achieved by including different property types of REITs in domestic mixed-asset portfolios across these three markets. The risk-adjusted performance comparisons were undertaken using the Jobson and Korkie pairwise test. The mean-variance model was utilised to assess roles of sector-specific REITs in mixed-asset portfolios. Asset allocation diagrams and efficient frontiers were used to present the optimum and constrained weights of sector-specific REITs in a multi-asset investment framework. A constrained portfolio framework was applied to constrain the REIT allocation at a maximum level of 20% in a mixed-asset portfolio, reflecting the typical actual total property allocation in institutional investor portfolios (NAREIT, 2019). The Microsoft Excel Solver was utilised to compute portfolio returns and risk of optimal and constrained multi-asset portfolios, as well as the weights of all assets. These analyses were expanded to accurately offer comparative performance and portfolio analyses between sector-specific REITs, diversified REITs and the other mainstream asset classes by dividing the full study timeframe into two sub-periods: pre-GFC and post-GFC.

The second methodological framework aims to address RQ3, examining the significance of Asia-Pacific-based sector-specific REITs in regional and global investment portfolios. This study extended the domestic methodological framework to regional and global investment perspectives. In a regional context, a regional sectoral REIT investment strategy was explored by providing comparative performance and portfolio analyses between sector-specific REITs, diversified REITs and the other mainstream asset classes. For this purpose, the six Asia-Pacific-based REIT sub-sector indices (office, retail, industrial, residential, specialty and diversified REITs) at the regional aggregative level were constructed to measure risk-return attributes, portfolio diversification benefits and roles in the regional mixed-asset portfolio for Asia-Pacific-based sector-specific REITs. In a global context, the potential of an Asia-Pacific sectoral REIT investment strategy for international listed property investors was assessed. Global stocks and composite REITs in the USA and Europe were employed as benchmark proxies.

The third methodological framework plans to answer RQ4, reflecting the market trend that international property funds have the practical mandate to gain exposure to regional REIT-based portfolios. Five different property types of Asia-Pacific REIT-based portfolios were analysed: office, retail, industrial, residential and specialty REIT-based portfolios. Each property type of regional REIT-based portfolio comprised the corresponding sector-specific REITs across Japan, Australia and Singapore, benchmarked against that in the USA. To highlight a cross-country sectoral REIT investment strategy, the optimum weights of the different property types of sector-specific REITs across these four markets in the corresponding regional REIT-based portfolio were analysed and reported. The findings particularly highlight geographic and sectoral diversifications of a cross-country sectoral REIT investment strategy.

Table 1-3: Summary of the use of methodologies and data in each research question

Research questions	Methodologies	Data
RQ1	1. The Sharpe ratio 2. The correlation coefficient 3. Jobson & Korkie (1981) pairwise test 4. Sub-period analysis	Constructed REIT sub-sector monthly TRI across Japan, Australia and Singapore
RQ2	1. Modern Portfolio Theory 2. Sub-period analysis	Constructed REIT sub-sector monthly TRI across Japan, Australia and Singapore
RQ3	1. The return/risk ratio 2. The correlation coefficient 3. Modern Portfolio Theory 4. Sub-period analysis	Constructed Asia-Pacific-based REIT sub-sector monthly TRI
RQ4	1. The return/risk ratio 2. The correlation coefficient 3. Modern Portfolio Theory 4. Sub-period analysis	Constructed sector-specific REIT monthly TRI across Japan, Australia and Singapore, as well as FTSE EPRA/NAREIT US sector-specific REIT monthly TRI
RQ5	1. GARCH-M specification 2. Sub-period analysis	Constructed REIT sub-sector daily TRI across Japan, Australia and Singapore
RQ6	1. The Sharpe ratio 2. The correlation coefficient 3. Jobson & Korkie (1981) pairwise test 4. Modern Portfolio Theory 5. GARCH-M specification 6. Sub-period analysis	FTSE EPRA/NAREIT US REIT sub-sector monthly TRI, as well as constructed US REIT sub-sector daily TRI

Note: TRI = Total Return Index

The last methodological framework targets RQ5, assessing the interest rate sensitivity of REITs at both the market and property sector levels. Using daily total returns from 19

July 2006 to 31 December 2018, an analysis was conducted of the interest rate sensitivity analysis of office, retail, industrial, residential, specialty and diversified REITs across Japan, Australia and Singapore. The rigorous interest rate sensitivity regression analysis was conducted using MATLAB 2019 and EViews 10 software programs and followed standard econometric procedure. Firstly, the autocorrelation function (ACF) was employed to test the suitability of a GARCH approach for modelling daily REIT sub-sector excess returns. Secondly, the augmented Dickey-Fuller (ADF) test was used to test whether time series data were non-stationary. Thirdly, a GARCH-M model was used to assess the sensitivity of sector-specific REITs to changes in the level and volatility of short- and long-term interest rate series. Last but not least, to reinforce the REIT specialisation value in the Asia-Pacific this study extended the performance, portfolio, interest rate sensitivity and sub-period analyses to the US-REIT market to validate the results (RQ6). In the interest rate sensitivity framework, daily total returns were sourced from the market value-weighted free-float-adjusted US-REIT sub-sector indices constructed for this study, with consideration of survival bias. **Table 1-3** summarises the use of methodologies and data series for each research question in this study.

1.6 THEORETICAL CONTRIBUTIONS OF THE STUDY

This study contributes to the previous literature in a number of ways. First of all, this study is the first to recognise the existence of REIT specialisation value in the Asia-Pacific markets across Japan, Australia and Singapore, with updated empirical evidence on the USA in the post-GFC context. Unlike previous scholarly studies – which, by considering different property types of REITs as a hybrid specialised REIT portfolio, disregard the fact that different property sectors may be characterised by various market fundamentals – this study is the first rigorous analysis to compare different property types of REITs with diversified REITs in domestic, regional and global investment contexts. Doing so contributes towards a comprehensive understanding of REIT specialisation value in the Asia-Pacific region and the US markets across multi-dimensional investment aspects of the significance, risk-adjusted returns, portfolio diversification benefits, added-value benefits and interest rate sensitivity of different property types of REITs, highlighting sector-specific REITs as the more effective REIT structure and primary conduit of listed property investment exposure for REIT investors and managers who actively diversify portfolios by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio.

Secondly, this study is the first to deliver a rigorously quantitative analysis of Asia-Pacific sector-specific REITs, reflecting the assertion of REIT specialisation value and offering critical insights into the dynamic investment of all property types of REITs in the Asia-Pacific region. Comprehensive and comparative investment performance analyses across three Asia-Pacific REIT markets and six REIT sub-sector markets delivers an in-depth understanding of cross-country and multi-sector investment performance and risk management strategies on a broad range of listed property investment platforms. In addition, this study constructs the efficient portfolio, optimum and constrained portfolio asset allocation strategies, with Asia-Pacific sector-specific REITs included as an added-value investment asset of mixed-asset portfolios in the domestic, regional and global perspectives. The empirical results contribute to a fuller understanding of the strategic investment implications of different property types of REITs for cross-border property investors and fund managers seeking effective cross-border property investment and expansion beyond their domestic property markets.

Thirdly, this research is the first rigorously empirical analysis to offer a comprehensive insight to the dynamic investment performance different property types of Asia-Pacific REIT-based portfolios, in order to satisfy the practical investment appetite for a fund with the mandate to gain exposure to regional REIT-based portfolios, as well as to reflect the sectoral effect in the Asia-Pacific REIT markets. The empirical results offer a comprehensive understanding of the dynamic portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of different property types of regional REIT-based portfolios, as well as the optimum weights of sector-specific REITs across Japan, Australia, Singapore and the USA within each property type of regional REIT-based portfolio. These findings contribute to comprehensive investment, portfolio diversifications and portfolio construction strategies for different property types of regional REIT-based portfolios for local and international investors and fund managers seeking listed property exposure in the Asia-Pacific investment space.

This study is also the first dedicated study to assess the interest rate sensitivity of different property types of REITs with respect to the assertion of REIT specialisation value in the property literature. Employing a GARCH-M specification, the empirical analysis scrutinises the interest rate sensitivity of REITs across three markets in the Asia-Pacific

(Japan, Australia, Singapore) in general and across different property types of REITs (office, retail, industrial, residential, specialty and diversified). The rigorously empirical results contribute to a deeper understanding of the dynamic multi-country and multi-sector interest rate risk management of different property types of REITs in the Asia-Pacific for international property investors constructing and managing portfolios so as to reduce or mitigate interest rate risk exposure.

Last but not least, to validate the REIT specialisation value in the Asia-Pacific, this study extends the performance, portfolio, interest rate sensitivity and sub-period analyses to the US-REIT market to validation the results of the Asia-Pacific analyses. All of these contribute to an improved understanding of REIT specialisation value in the Asia-Pacific region and the USA, as well as the distinct investment attributes of different property types of REITs.

1.7 THESIS OUTLINE

Figure 1-4 depicts the overall structure of this thesis. The thesis is structured into ten chapters comprising the introduction (Chapter 1), market analysis (Chapter 2), literature review (Chapter 3), data and methodology (Chapter 4), analysis and findings (Chapter 5–Chapter 8), the validated results from the US-REIT market (Chapter 9) and conclusions (Chapter 10). Chapters 5, 6, 7, 8 and 9 address the six research questions.

Chapter 1 introduces the contextual framework, providing a brief introduction to REITs, specialisation value, research gaps, questions, objectives, dataset and methodology, contributions and the general layout of the research.

Chapter 2 offers an overview of the background of the Asia-Pacific REIT markets, and continues with the significant status of the Asia-Pacific REIT markets in the global investment space. This chapter proceeds with an analysis and discussion of the profiles of current Asia-Pacific REITs from, an investment perspective, as well as the market players. The significance of Asia-Pacific sector-specific REITs is also highlighted. In particular, the category defined by the GICS, market size breakdown and company profiles for REIT sub-sectors across 13 REIT markets in the Asia-Pacific (Japan, Australia, Singapore, Hong Kong, Malaysia, New Zealand, Taiwan, Thailand, South Korea, Pakistan, Indonesia) are discussed. This chapter aims to highlight the central research gap in the body of knowledge on this topic – the REIT specialisation value (RQ1) – via the observation of the unique market phenomenon of sector-specific REITs in the Asia-Pacific REIT investment space.

Chapter 3 aims to identify the main research question by providing a comprehensive review of the international scholarly literature on property markets fundamentals, the segmentation theory and firm specialisation theory. Subsequently, the sections primarily focus on the performance, diversification benefits and strategic portfolio allocations of sector-specific REITs, particularly highlighting these issues in the Asia-Pacific region. Given the large volume of scholarly literature on these aspects in the theoretical domain, the sub-chapter is divided into two sections, namely the US and European sector-specific REITs and Asia-Pacific sector-specific REITs. The discussion of Asia-Pacific sector-specific REIT consists of three geographical sections covering Japan, Australia and Singapore. Lastly, the relevant international scholarly literature researching interest rate sensitivity of REITs is underlined. This chapter aims to strengthen the conceptual framework of this research with a comprehensive theoretical background and to identify the paucity of literature on the sector-specific REIT investment space.

Chapter 4 outlines the data and research methodologies employed in this study, delivering a detailed description of the data sources, constructed indices and analytical terminologies. The performance measures, portfolio analysis and regression models employed in this study are explained in detail.

Chapters 5 and 6 report the empirical findings on the investment performance of different property types of REITs benchmarked against diversified REITs and the other mainstream asset classes in domestic, regional and international investment contexts. These two chapters are divided based on five separate methodological constructs: (1) a performance analysis comprising the return, risk, and risk-adjusted return analyses; (2) a portfolio diversification analysis measured by the correlation coefficient analysis; (3) a risk-adjusted performance comparison evaluated by the Jobson and Korkie pairwise test; (4) a mixed-asset portfolio allocation calculated by a mean-variance asset allocation analysis; and (5) a sub-period analysis. Chapter 5 aims to address the first and second research questions (RQ1 and RQ2), illustrating the empirical results for sector-specific REITs from a domestic investment perspective, including the findings of the three Asia-Pacific REIT markets across Japan, Australia and Singapore. Chapter 6 is designed to answer the third research question (RQ3), documenting the empirical results of sector-specific REITs from the regional and global investment perspectives and extending the above analyses to the regional and global investment contexts.

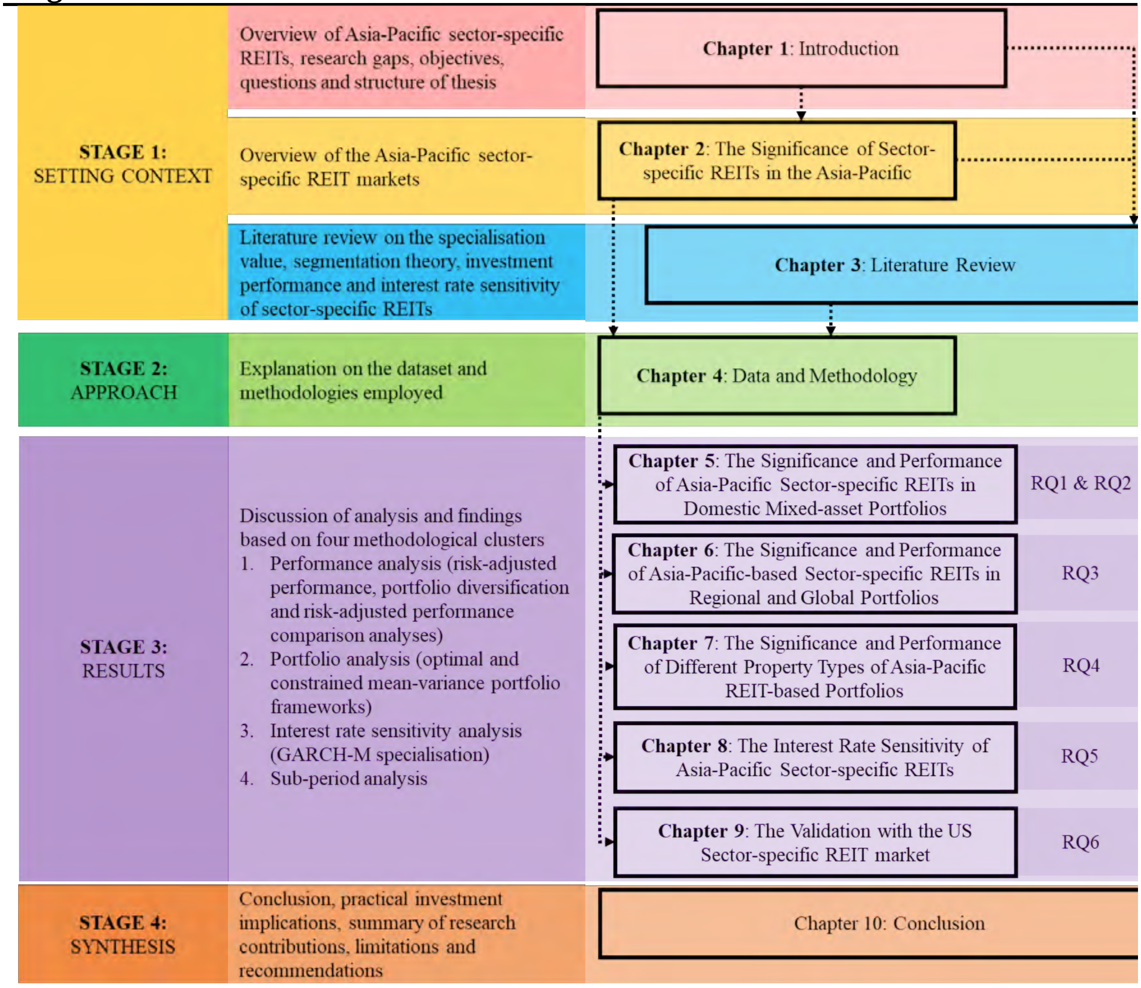
Chapter 7 aims to address the fourth research question (RQ4), reporting the empirical results of the dynamic portfolio returns, risk, geographic and sectoral diversifications and asset allocations for different property types of regional REIT-based portfolios in the Asia-Pacific, including regional office, retail, industrial, residential and specialty REIT portfolios. This chapter offers comprehensive insights into the portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of five different property types of regional REIT-based portfolios in the Asia-Pacific region.

Chapter 8 is structured to address the fifth research question (RQ5), investigating the interest rate sensitivity of Asia-Pacific sector-specific REITs at both the market and sector levels. The analyses are conducted using the GARCH-M specification. These include three Asia-Pacific REIT markets (Japan, Australia, Singapore) and six REIT sub-sectors (office, retail, industrial, residential, specialty and diversified).

Chapter 9 aims to answer the final research question (RQ6), validating the results of the specialisation value in the Asia-Pacific markets against the US-REIT market. This chapter follows the preceding methodological frameworks: the performance, portfolio, interest rate sensitivity and sub-period analyses, in order to assess the REIT specialisation value in the USA.

The research concludes in Chapter 10, which summarises the main findings on the risk-adjusted investment performance, portfolio diversification benefits, roles in mixed-asset portfolios in domestic, regional and global investment contexts and the interest rate sensitivity of Asia-Pacific sector-specific REITs. This chapter also discusses the theoretical contributions and strategic investment implications of this research, as well as highlighting its limitations and recommending potential future research directions.

Figure 1-4: Structure of the thesis



Source: Author's compilation

CHAPTER 2
THE SIGNIFICANCE OF SECTOR-SPECIFIC REITS IN THE ASIA-PACIFIC

Chapter 2 highlights the significance of sector-specific REITs in the Asia-Pacific region. This includes the alignment of the Asia-Pacific property markets and Asia-Pacific capital markets in the context of the global property investment space, with detailed analyses of sector-specific REITs in the Asia-Pacific at a country level.

2.1 INTRODUCTION

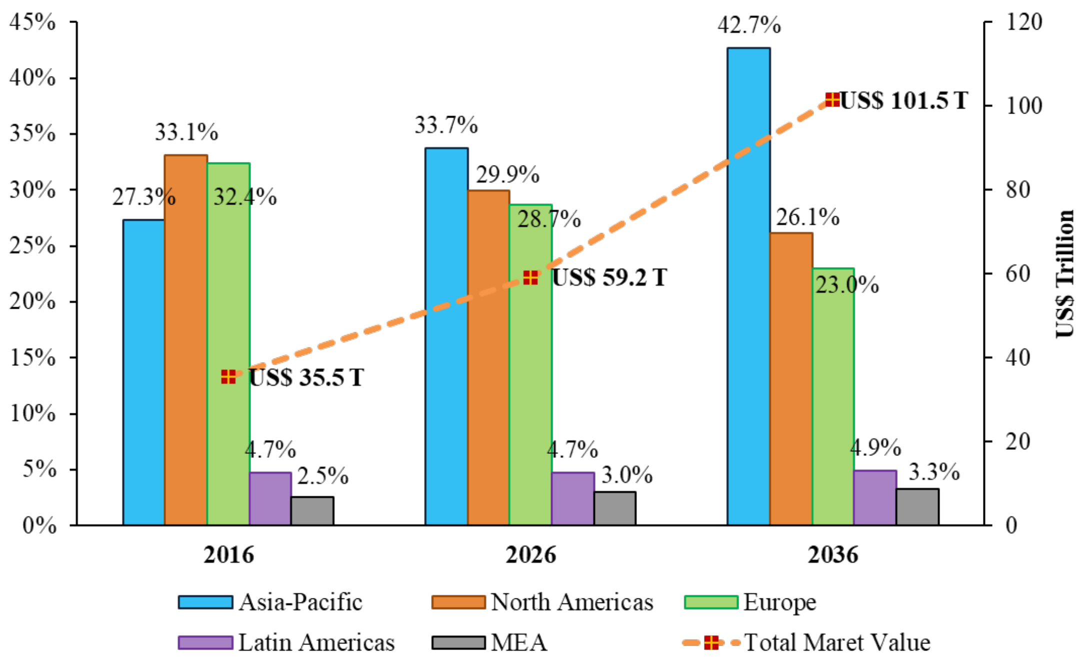
This chapter discusses the profiles and growth in market capitalisation of different property types of REITs across 11 markets in the Asia-Pacific region, in order to highlight the trend of sector-specific REITs playing a prevailing role over the last 12 years (July 2006–December 2018). Detailed statistics are sourced from the dataset constructed for this research.

2.2 OVERVIEW OF THE ASIA-PACIFIC PROPERTY MARKETS

2.2.1 Size of Asia-Pacific Property Markets

The Asia-Pacific has been a significant contributor to the international property investment space in recent years. **Figure 2-1** indicates that the Asia-Pacific was the third-largest regional property markets in the global context in 2016, and was forecast to grow to US$15.6 trillion by 2026 and US$32.8 trillion by 2036 (PREI, 2017a). As the largest regional property market in the next two decades, the Asia-Pacific will be two times larger than North America in 2036 and will also exceed other regional property markets (PREI, 2017a). In 2018, the Asia-Pacific (No. 2 globally) contributed 30.7% of the total assets of the global property market, accounting for US$8.8 trillion, ahead of Europe (No. 3; US$8.6T; 30.0%) and the Middle East and Africa (MEA) (No. 4; US$0.9T; 3.1%), but slightly exceeded by North America (No. 1; US$10.4T; 36.2%) (EPRA, 2018c). To reinforce the importance of the Asia-Pacific property markets in the international context, **Table 2-1** lists the leading global commercial property markets as of December 2018. China is the second-largest commercial property market globally, accounting for US$3.5 trillion and representing 12.1% of the size of the global commercial property market, ahead of Japan (No. 3; US$2.2T; 7.6%), Germany (No. 4; US$1.6T; 5.6%), the UK (No. 5; US$1.5T; 5.4%), France (No. 6; US$1.2T; 4.0%), Italy (No. 7; US$0.9T; 3.0%), Canada (No. 8; US$0.7T; 2.5%), South Korea (No. 9; US$0.7T; 2.3%) and Brazil (No. 10; US$0.6T; 2.2%); but exceeded by the USA (No. 1; US$8.5T; 29.5%). Of the top 10 global commercial property markets, three are from the Asia-Pacific, namely China, Japan and South Korea. Australia is ranked at 11, accounting for US$0.6 trillion and contributing 2.1% of the global commercial property market. Importantly, the total assets of these four commercial property markets account for US$6.9 trillion, contributing over 24.0% of the market value of the global commercial property market. These figures illustrate the status of the Asia-Pacific in the context of the global property investment space.

Figure 2-1: Global property market size: 2016–2036



Source: Author's compilation/analysis from PREI (2017a)

Table 2-1: Leading international commercial property markets: December 2018

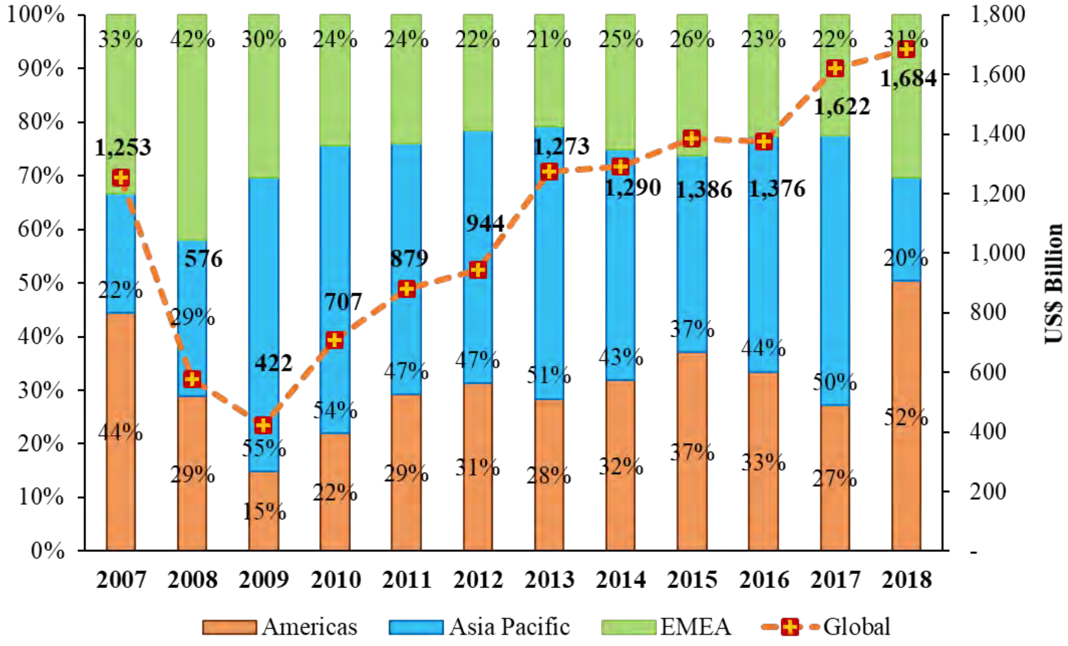
Rank	Country	Market Cap (US$ T)	% of Global Property Market
1	US	8.5	29.5
2	**China**	**3.5**	**12.1**
3	**Japan**	**2.2**	**7.6**
4	Germany	1.6	5.6
5	UK	1.5	5.4
6	France	1.2	4.0
7	Italy	0.9	3.0
8	Canada	0.7	2.5
9	**South Korea**	**0.7**	**2.3**
10	Brazil	0.6	2.2
	Total	21.3	74.1
Global property market		28.7	100.0

Source: Author's compilation from EPRA (2018c)

2.2.2 Property Transactions in the Asia-Pacific

The property transaction is a signal of the status of property investment activities (RCA, 2018b), signifying the attributions of the property market: property capitalisation yields, investment performance and volatility of assets, and investor confidence to the property market (CBRE, 2018c). This section describes the status of Asia-Pacific property investment activities by assessing Asia-Pacific property transactions from 2007 to 2018, in order to reinforce the significance of the Asia-Pacific property markets. **Figure 2-2** shows that investment activity in the global property market is substantial, recording US$1,683.7 billion in 2018 – the highest level since 2007. During the 2008 GFC, global commercial property transaction volumes experienced a major downturn, reaching their lowest level of US$422.4 billion in 2009 and only returning to the pre-GFC level from 2013. Since the downturn in 2009, the Asia-Pacific has been a significant property investment focus at a global level, averagely contributing 43.5% of annual global commercial property investment activities over the last 11 year and exceeding the Americas (29.9%), Europe, and Middle East and Africa (EMEA) (26.6%) over the same period. The activity in Asia-Pacific commercial property transactions has strengthened the critical status of the Asia-Pacific in the international property investment space.

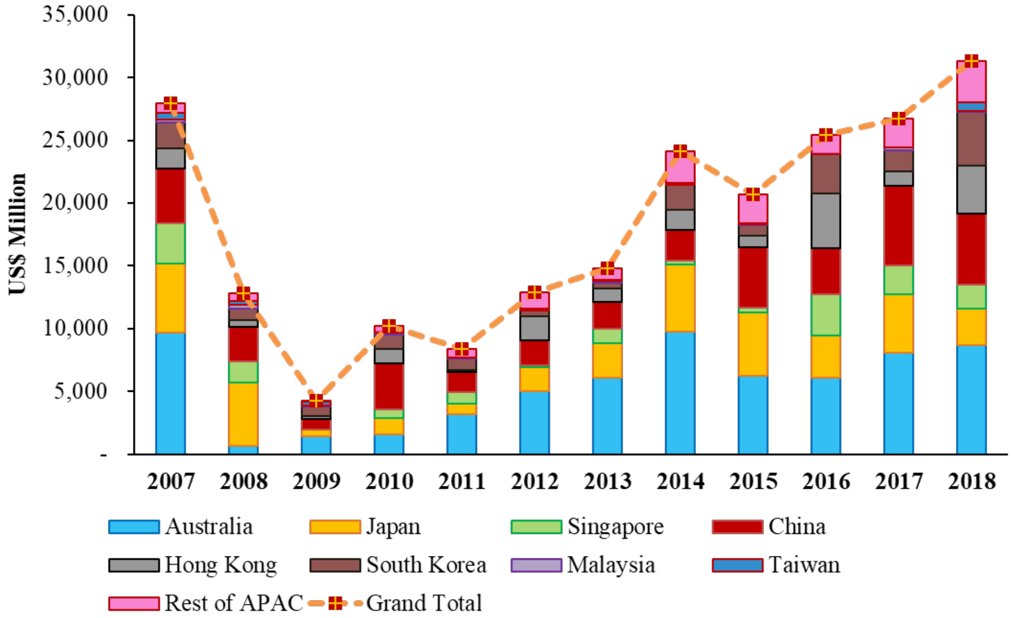
Figure 2-2: Regional property transactions globally: 2007–2018



Source: Author's compilation/analysis from RCA database (2007–2018)

In the Asia-Pacific context, active commercial property investment transactions have been mainly led by Australia, Japan, China and Singapore over the past 12 years, as presented in **Figure 2-3**. The total volumes of these four markets contributed 72.7% of the Asia-Pacific total, increasing by 110% since 2007. **Table 2-2** lists the most active Asia-Pacific commercial property markets in 2018. In 2018, China (No. 1) was the most active market in the region but dropped 6% YOY to US$36.9 billion. This may be attributed to capital control rules in China (RCA, 2018a). A similar trend was observed in Australia (No. 3), which dipped 10% YOY to US$23.8 billion in 2018, due to lower-yielding and high-pricing assets in Australia (CBRE, 2018a). In contrast, Japan was ranked second in the Asia-Pacific, with a slight increase of 3% YOY to US$34.9 billion in 2018. This was supported by the ongoing weakened currency rate and low-interest rate environment (CBRE, 2018a). Singapore increased 50% YOY to US$9.0 billion in 2018, ranking sixth in the Asia-Pacific. These figures show Australia, Japan, China and Singapore as the core property investment conduits in the Asia-Pacific commercial property investment space.

Figure 2-3: Asia-Pacific commercial property transactions: 2007–2018



Source: Author's compilation/analysis from RCA database (2007–2018)

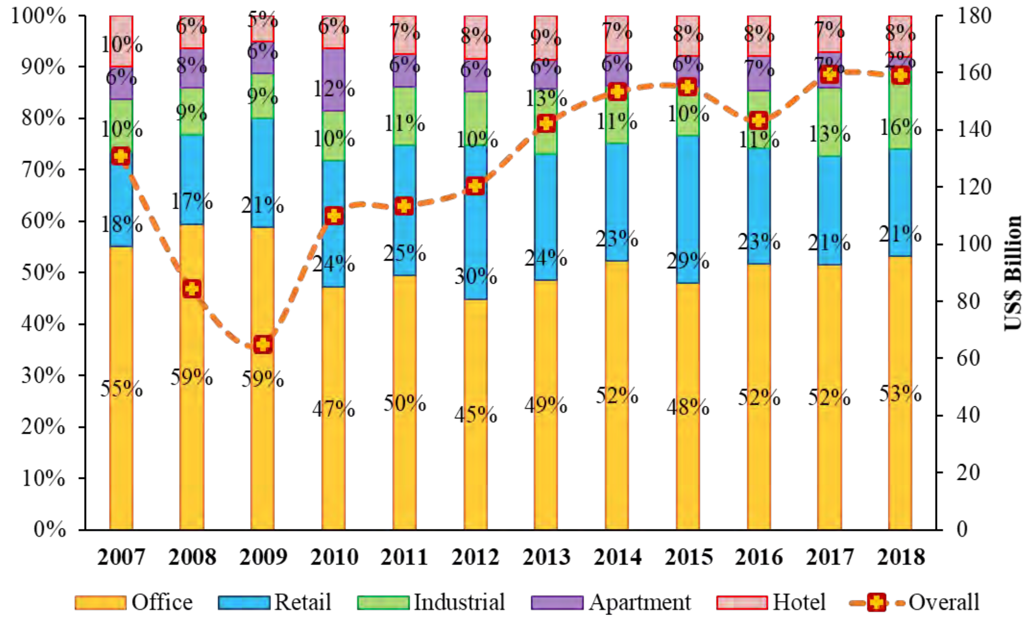
Table 2-2: Most active Asia-Pacific commercial property markets: 2018

Rank	Markets	Commercial Property Transaction (US$ B)	YOY (%)
1	China	31.3	−14
2	Australia	28.8	−2
3	Japan	28.8	−26
4	Hong Kong	25.7	32
5	South Korea	22.7	43
6	Singapore	7.5	−15
7	Taiwan	4.6	91
8	India	4.4	4
9	New Zealand	2.2	−22
10	Thailand	1.4	73
	Total	159.1	5

Source: Author's compilation from RCA (2018a)

At a property sector level, **Figure 2-4** displays commercial property acquisitions by property types in the Asia-Pacific from 2007 to 2018. Office property has been the main investment property focus in the Asia-Pacific investment space over the last 12 years, contributing an average of 51.6% of Asia-Pacific commercial property transactions and setting a record level at US$82.2 billion in 2017. Retail properties (25.3%) have been rated second, peaking at US$44.5 billion in 2015 but dramatically dropping by 27.2% YOY in 2016 and 24.5% YOY in 2017. Retail was followed by industrial (No.3; 10.7%), hotel (No. 4; 7.5%) and apartment properties (7.0%). Industrial properties reached their highest level at US$21.0 billion in 2017 and represented 13.2% of Asia-Pacific commercial property transactions over the period.

Figure 2-4: Commercial property acquisitions by property types in the Asia-Pacific: 2007–2018

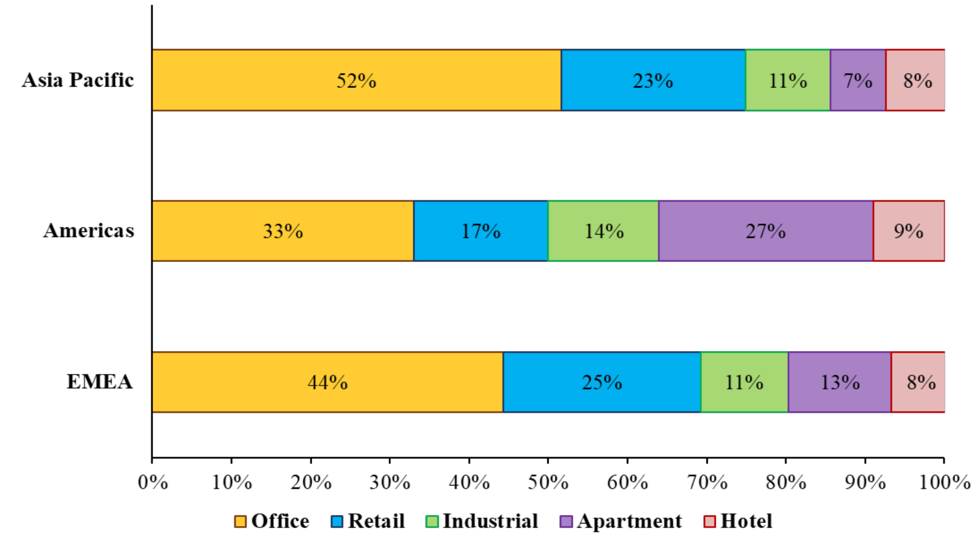


Source: Author's compilation/analysis from RCA database (2007–2018)

Figure 2-5 presents average global commercial property transactions by property type from 2007 to 2018. Compared to the Americas (33%) and EMEA (44%), investment activities in the Asia-Pacific more concentrated on office properties (52%), which contributed over half of the total commercial property acquisitions in the region and accounted for an annual average of US$64.2 billion over the past 12 years. On the other hand, apartment properties played the smallest role (7%) in the Asia-Pacific commercial property transactions, in contrast to the same transaction in the Americas (27%) and EMEA (13%). This may be attributed to a common misperception of commercial residential property investment as a high-risk investment asset for institutional investors (Milligan *et al.*, 2013; Moss and Prima, 2014; Newell *et al.*, 2015; Lin *et al.*, 2019b).

For the other property sectors in the Asia-Pacific, the percentages of retail (23%) and industrial properties (11%) to the total commercial property acquisitions were comparable to those in the Americas (17%; 14%) and EMEA (25%; 10%) over the last 12 years. In a CBRE (2018c) report, Asia-Pacific retail sales were mostly driven by China (US$1.4B) and India (US$1.3B) in 2017. This may be attributed to the large populations in these two markets. Transaction volumes by industrial properties were forecast to continue in the future, owing to the substantial increase of the e-commerce industry, development of logistics properties and strong consumption in the Asia-Pacific, as reported by CBRE (2018a). The Asia-Pacific hotel property markets were driven by a substantial increase in both domestic and international tourism in the region, led by Melbourne, Sydney, Tokyo, Osaka, Singapore and Hong Kong (CBRE, 2018b).

Figure 2-5: Average global commercial property transactions by property types: 2007–2018



Source: Author's compilation/analysis from RCA database (2007–2018)

2.2.3 Key Drivers of Asia-Pacific Property Markets

The Asia-Pacific property markets were bolstered by the strong population demographics, GDP growth, high consumption and solid property market fundamentals in the region (CBRE, 2018a, b). In particular, the fast-growing population and strong GDP growth in the Asia-Pacific are considered two key drivers of accelerating, stable and long-term demand for commercial properties in the Asia-Pacific over the next few years (JLL, 2016a; CBRE, 2018a, b). **Table 2-3** provides population demographics, GDP and GDP growth for leading Asia-Pacific property markets in 2018. China (No. 1) is the most populous country in the international and Asia-Pacific contexts, with a population of 1.4 billion. At the same time, it contributed 16.5% of the world economic output and was the second-largest economy in the international context, with a GDP growth of 6.6% (EPRA, 2018c). Over 59.2% of the total population in China is concentrated in metropolitan areas such as Beijing, Shanghai and Shenzhen (CIA, 2018). India had the second-largest population

(1.3B) in the international and Asia-Pacific contexts, with GDP growth of 7.3%. However, urbanisation in India (34.0%) is lower than in Japan (91.6%), Singapore (100.0%) and Australia (86.0%) (CIA, 2018). Japan is the tenth most populous country (126.0M) in the international context. 91.6% of the population is clustered in metropolitan areas such as Tokyo (37.5M) and Osaka (19.3M) (CIA, 2018). It contributed 6.1% of the world economic output, as the fourth largest economy at a global level, with a low unemployment rate (2.9%; No. 34 globally) (CIA, 2018). Meanwhile, Australia had a population of 23.5 million (No. 56 globally) and contributed 1.9% of the world economic outputs, as the nineteenth largest economy at a global level, with GDP growth at 3.2%. Singapore generated 0.4% of the global economic output, as the thirty-eighth economy at a global level, with 6.0 million people. The strong demographics and healthy GDP outputs have provided the potential for solid property markets fundamentals in the commercial property investment space in the Asia-Pacific over the next few years (JLL, 2016a, CBRE, 2018a, b; PREI, 2017b).

The Asia-Pacific property markets have also improved access to investment property in recent years, in order to allow investors to make decisions and operate with confidence and efficiency (JLL, 2018). According to JLL's global property transparency index, the depth of the property market fundamental data was the most significant driver of improvement in the property markets in the Asia-Pacific, including in Japan (No. 19), Taiwan (No. 22), China (No. 32), India (No. 35) and South Korea (No. 38), as documented in **Table 2-4**. Furthermore, Australia (No. 2) was classified as a "highly transparent" property market in 2018, while Singapore (No. 11) and Hong Kong (No. 15) were also ranked as transparent. Since the Asia-Pacific property markets have improved access to property investment, the Asia-Pacific has offered accessible property investment channel for investors in the international context.

Table 2-3: Populations and GDP growth in the Asia-Pacific: 2018

Market	Populations (M)	GDP (US$ B)	GDP growth (%)
China	1,396.98	13,457.27	6.60
India	1,334.22	2,689.99	7.30
Japan	126.43	5,070.63	1.14
Australia	25.18	1,427.77	3.24
Singapore	5.67	346.62	2.93
Hong Kong	7.47	360.32	3.78
Malaysia	32.45	347.29	4.70
New Zealand	4.95	206.00	3.07
Taiwan	23.60	602.68	2.73
Thailand	69.18	490.12	4.60
South Korea	51.66	1,655.61	2.76
Philippines	107.02	331.68	6.52
Indonesia	265.32	1,005.27	5.14
Pakistan	200.96	306.90	5.79
Total	3,651.09	28,298.15	(an average) 6.34

Source: Author's compilation from CIA (2018), EPRA (2018c) and IMF (2018)

Table 2-4: Global property transparency ranking: 2018

Highly transparent UK, **Australia (#2)**, Canada, US, France, New Zealand, Netherland, Ireland, Germany, Finland
Transparent **Singapore (#11)**, Sweden, Poland, Switzerland, **HK (#15)**, Belgium, Denmark, Norway, **Japan (#19)**, Italy, Spain, **Taiwan (#22)**, Austria, South Africa, Hungry, Portugal, **Malaysia (#27)**, Slovakia, Romania
Semi-transparent Israel, Mexico, **China (#32)**, Brazil, Luxembourg, **India (#35)**, Greece, **Thailand (#37)**, **South Korea (#38)**, Botswana, Russia, Turkey, Indonesia, **Philippines (#43)**, Croatia, Dubai, Bulgaria, Slovenia, Serbia
Low transparent **Vietnam (#49)**, **Macau (#50)**, Morocco, Uruguay, Kuwait, Qatar, Ukraine, Puerto Rico, Iran, Jordan
Opaque Oman, Uganda, Lebanon, Panama, Tunisia

Source: JLL (2018)

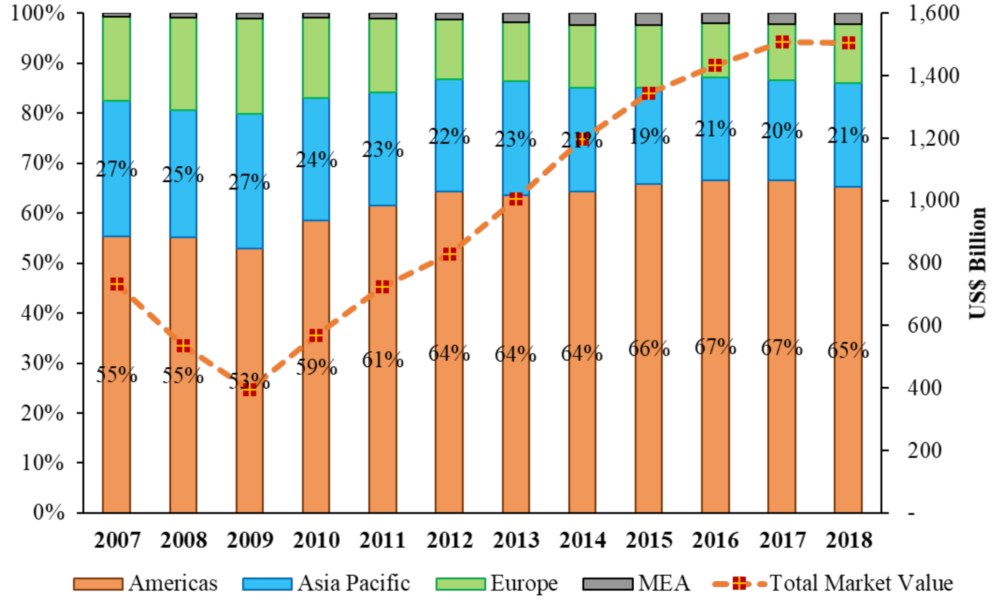
2.3 SIGNIFICANCE OF REITs IN THE ASIA-PACIFIC

2.3.1 Size of Asia-Pacific REITs

The increasingly significant status of the Asia-Pacific property markets has been highlighted in the preceding sections. As a significant listed property investment channel, REITs reflect the investment performance of direct property in the longer-term. Furthermore, they have been shown to be a close substitute for direct property in mixed-asset portfolios, with greater liquidity, higher transparency, substantial and stable dividend yields, lower transaction costs, lower performance and cost management structures, and strong portfolio diversification benefits, in addition to the existence of the public markets for property securities (Ooi *et al*., 2006; Horrigan *et al*., 2009; Lee and Ting, 2009; Ong *et al*., 2011; Lee *et al*., 2014; Newell *et al*., 2015; Sing *et al*., 2016). These factors have led several professional bodies, such as the Asia Pacific Real Estate Association (APREA), Association for Real Estate Securitisation (ARES), European Public Real Estate Association (EPRA) and Property Council of Australia (PCA), to offer research and market information on Asia-Pacific REITs for international scholars, practitioners and policymakers seeking listed property exposure in the Asia-Pacific region.

Figure 2-6 and **Table 2-5** portray the significance of Asia-Pacific REITs by market capitalisation from 2007 to 2018. While the Americas (an average 61.7% of the global REIT market) were a prominent player in the international REIT market in the past 12 years, the Asia-Pacific was the second-largest regional REIT market at a global level in terms of the market capitalisation and numbers of REITs. With 245 REITs and a market capitalisation of US$327.8 billion, the Asia-Pacific has averagely contributed 22.8% of the market capitalisation of the global REIT market over the last 12 years. In 2018, REITs contributed 22.9% and 3.8% of the total assets of the listed property markets and commercial property markets respectively in the Asia-Pacific. The low ratio of REITs to the Asia-Pacific commercial property markets can be attributed to the fact that REITs have yet to be introduced in China, the second-largest commercial property market in the international context (EPRA, 2018c).

Figure 2-6: Significance of Asia-Pacific REITs by market cap: 2007–2018



Source: Author's compilation from Thomson Reuters Eikon

Table 2-5: Profiles of regional REIT markets: December 2018

Region	No. of REITs	Market cap (US$ B)	% of Global REIT Market
Americas	277	1,061.6	65.8
Asia-Pacific	**247**	**327.8**	**20.4**
Europe	190	193.8	12.0
MEA	66	27.5	1.7
Total	780	1,610.7	100.0

Source: Author's compilation/analysis from EPRA (2018c) and the constructed database

Table 2-6: Profiles of leading global REITs: December 2018

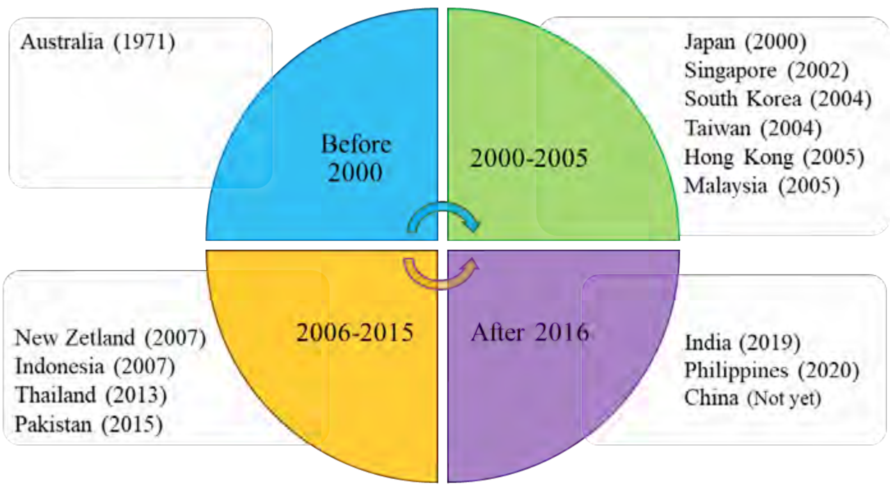
Rank	Market	No. of REITs	Market cap (US$ B)	% of Global REITs
1	US	195	996.9	61.8
2	**Japan**	**59**	**111.8**	**6.9**
3	**Australia**	**46**	**89.6**	**5.6**
4	UK	57	67.4	4.2
5	**Singapore**	**40**	**62.6**	**3.8**
6	France	27	50.5	3.1
7	Canada	46	48.5	3.0
8	**Hong Kong**	**10**	**35.6**	**2.2**
9	Netherlands	5	25.6	1.6
10	Spain	63	24.1	1.5

Source: Author's compilation/analysis from EPRA (2018c) and the constructed database

To reinforce the significant status of the Asia-Pacific REITs at a global level, **Table 2-6** lists leading global REITs in 2018. Japan was recorded as the second-largest REIT market at a global level, accounting for US$114.1 billion and representing 6.5% of the total assets of the global REIT market. It was only exceeded by the USA (No. 1; US$1,079.6B; 62.0% of the size of the global REIT market), and was followed by Australia (No. 3; US$89.8B; 5.2%), the UK (No. 4; US$76.3B; 4.4%), France (No. 5; US$59.2B; 3.4%), Canada (No. 6; US$56.6B; 3.2%), Singapore (No. 7; US$55.3B; 3.2%), Hong Kong (No. 8; US$34.3B; 2.0%), the Netherlands (No. 9; US$32.5B; 1.9%) and Spain (No. 9, US$25.4B; 1.5%). Of the ten leading global REIT markets, four were in the Asia-Pacific region. With 163 REITs, these four REIT markets accounted for US$293.5 billion, or 16.8% of the global REIT market.

Figure 2-7 shows the timeline of the Asia-Pacific REIT markets. Since the first REIT was introduced in 1971, the Asia-Pacific REIT markets have accumulated market capitalisation of US$327.8 billion, with 247 REITs across these 13 jurisdictions, including Australia (first REIT launched in 1971), Japan (2000), Singapore (2002), South Korea (2004), Taiwan (2004), Hong Kong (2005), Malaysia (2005), New Zealand (2007), Indonesia (2007), Thailand (2013) and Pakistan (2015) before 2018. In recent years, India and the Philippines have launched their first REITs, in 2019 and 2020 respectively. Given the diverse regulatory and market environments, Asia-Pacific REITs have distinct and unique features on the REIT structures across these 13 markets.

Figure 2-7: Timeline of REIT launches in the Asia-Pacific

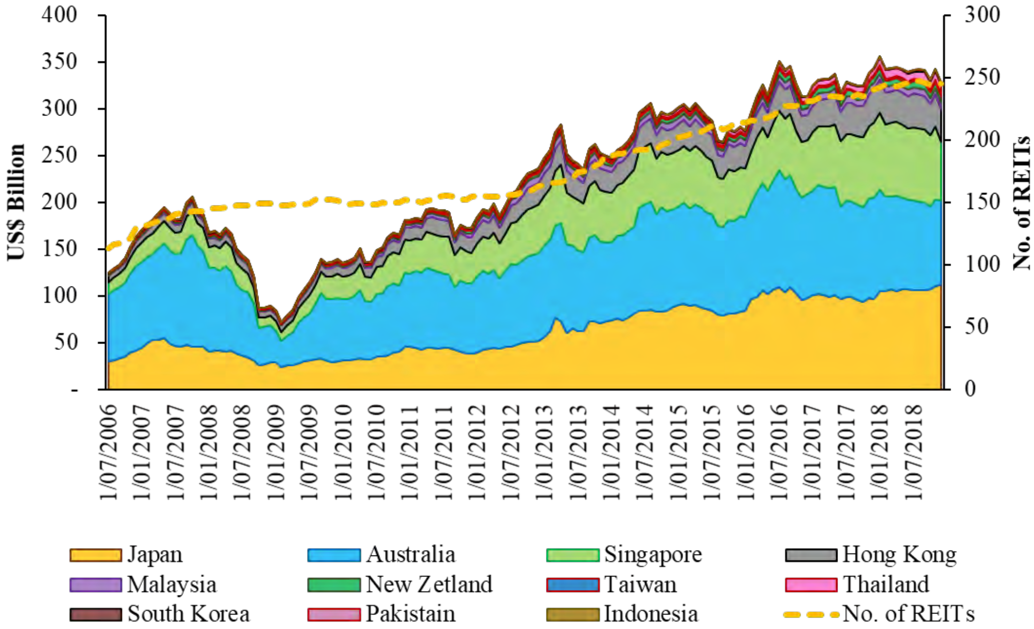


Source: Author's compilation from EPRA (2018a, 2019, 2020)

Figure 2-8 shows that Asia-Pacific REITs have increased from US$124.1 billion in July 2006 to US$327.8 billion in December 2018, a 2.6-fold increase since July 2006. **Table 2-7** articulates the profiles of Asia-Pacific REITs in 2018. Among the developed Asia-Pacific REIT markets' slice of US$308.1 billion, the key markets are Japan (No. 1 in the Asia-Pacific; US$111.8B; 34.1% of Asia-Pacific REITs), Australia (No. 2; US$89.6B; 27.3%), Singapore (No. 3; US$62.6B; 18.9%), Hong Kong (No. 4; US$35.6B; 10.9%), New Zealand (No. 7; US$6.5B; 1.3%) and South Korea (No. 9; US$2.0B; 0.6%). Among the emerging Asia-Pacific REIT markets, worth US$19.7 billion, are Thailand (No. 5; US$10.3B; 3.2%), Malaysia (No. 6; US$6.7B; 2.0%), Taiwan (No. 8; US$2.6B; 10.%), Pakistan (No. 10; US$0.2B; 0.1%) and Indonesia (No. 11; US$190M; 0.0%). By market capitalisation, REITs in Japan (J-REITs), Australia (A-REITs) and Singapore (S-REITs) are the top three REITs in the Asia-Pacific. With total assets of US$264.0 billion and 145 REITs, these three markets represent 80.3% of Asia-Pacific REITs and 16.3% of the global REIT market. An interesting aspect of the Asia-Pacific REIT markets is that significant China property exposure has been listed on the REIT markets in Singapore and Hong Kong (HK-REITs). Besides, Islamic REITs have been seen in Singapore and Malaysia (M-REITs) (EPRA, 2018a).

The abovementioned details highlight the significant status of Asia-Pacific REITs in the international REIT investment space, with Japan, Australia and Singapore as the major contributors to the Asia-Pacific REIT markets. Capturing the growth of the Asia-Pacific property markets, REITs in the Asia-Pacific have seen rapid growth by market capitalisation and number of funds in recent years.

Figure 2-8: Growth in market capitalisation for Asia-Pacific REITs: 11 markets: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

Table 2-7: Profiles of Asia-Pacific REITs: December 2018

Rank	Market	No. of REITs	Market cap (US$B)	% of Asia-Pacific REITs	% of Global REITs
1	**Japan**	**59**	**111.8**	**34.1**	**6.9**
2	**Australia**	**46**	**89.6**	**27.3**	**5.6**
3	**Singapore**	**40**	**62.6**	**18.9**	**3.8**
4	Hong Kong	10	35.6	10.9	2.2
5	Thailand	50	10.3	3.2	0.7
6	Malaysia	17	6.7	2.0	0.4
7	New Zealand	8	6.5	2.0	0.4
8	Taiwan	7	2.6	1.0	0.2
9	South Korea	8	2.0	0.6	0.1
10	Pakistan	1	0.2	0.1	0.0
11	Indonesia	1	0.0	0.0	0.0
	Total	247	327.8	100.0	19.3

Source: Author's compilation/analysis from EPRA (2018c) and constructed database

2.3.2 Players in Asia-Pacific REITs

Given the solid property market fundamentals and significant status of Asia-Pacific REITs in the international REIT investment space, they have become increasingly attractive to property investors in recent years. Asia-Pacific REITs have several experienced fund managers. **Table 2-8** lists leading REITs in the Asia-Pacific in 2018.

These include Link REIT (No. 1 in the Asia-Pacific; US$21.4B, retail), Scentre Group (No. 2; US$14.6B, retail), Goodman (No. 3; US$13.6B, industrial), Nippon Building Fund (No. 4; US$8.9 B; office), Japan Real Estate Investment (No. 5; US$7.8B; office), Dexus (No. 6; US$7.6B; office), Vicinity Centres (No. 7; US$7.0B; retail), GPT (No. 8; US$6.8 B; diversified), Capitaland Mall Trust (No. 9; US$6.1B; retail) and Stockland (No. 10; US$6.0B; diversified). The top 10 Asia-Pacific REITs accounted for US$99.8 billion, being 30.45% of the total assets of Asia-Pacific REITs.

To reinforce the significance of Asia-Pacific REITs in the international context, **Table 2-9** tabulates the profiles of the top 15 REITs at a global level. Of 15 leading global REITs, three are in the Asia-Pacific, namely Link REIT (No. 8 globally; Hong Kong), Scentre Group (No. 13; Australia) and Goodman (No. 14; Australia). This has made Asia-Pacific REITs a key REIT investment focus for institutional investors at Asia-Pacific and global levels.

Table 2-8: Profiles of leading REITs in the Asia-Pacific: December 2018

Rank	REITs	Market	Property type*	Market cap (US$B)
1	Link REIT	HK	Retail	21.4
2	Scentre Group	Australia	Retail	14.6
3	Goodman	Australia	Industrial	13.6
4	Nippon Building Fund	Japan	Office	8.9
5	Japan Real Estate Investment	Japan	Office	7.8
6	Dexus	Australia	Office	7.6
7	Vicinity Centres	Australia	Retail	7.0
8	GPT Group	Australia	Diversified	6.8
9	Capitaland Mall Trust	Singapore	Retail	6.1
10	Stockland	Australia	Diversified	6.0

Note: * categorised by the GICS
Source: Authors’ compilation from EPRA (2018b)

Table 2-9: Profiles of leading global REITs: December 2018

Rank	Company	Market	Property type*	Market cap (US$B)
1	Simon Property Group	US	Retail	53.8
2	ProLogis	US	Industrial	37.0
3	Public Storage	US	Specialty	35.3
4	Welltower	US	Specialty	26.1
5	Equity Residential	US	Residential	24.4
6	AvalonBay Communities	US	Residential	24.1
7	Digital Realty	US	Specialty	22.0
8	**Link REIT**	**HK**	**Retail**	**21.4**
9	Ventas	US	Specialty	20.9
10	Realty Income	US	Retail	18.6
11	Boston Properties	US	Office	17.4
12	Essex Property Trust	US	Residential	16.2
13	**Scentre Group**	**Australia**	**Retail**	**14.6**
14	**Goodman**	**Australia**	**Industrial**	**13.6**
15	Health Care Property Investors	US	Specialty	13.3

Note: * categorised by the GICS
Source: Authors' compilation from EPRA (2018b)

With stable and long-term income stream and dividends, and the added benefits of liquidity, transparency and fiscal efficiency, and lower expenses and corporate governance, REITs have received an increased level of institutional investor attention in recent years (NAREIT, 2019). In particular, property-related portfolio diversifications are often commenced in REITs by institutional investors, who are not willing to own physical properties (Devos *et al*., 2013; Aguilar *et al*., 2018; Liang *et al*., 2019). Since the adoption of REITs into the Standard and Poor's (S&P) indices in 2001, institutional ownership of total ownership in REITs has increased from 14.1% in 1990 to 75.2% in 2011 (An *et al*., 2016). Compared with direct property, the level of passive institutional ownership in REITs has doubled since 2001 (Aguilar *et al*., 2018). The preference of institutional investors is for larger and more liquid REITs (Ciochetti *et al*., 2002). In addition, office, industrial and residential REITs are documented as possessing a higher level of institutional ownership than other REIT sub-sectors (Feng *et al*., 2011). These institutional investors include pension funds, insurance companies, investment companies, bank trusts, endowments and foundations (Devos *et al*., 2013; Aguilar *et al*., 2018; Liang *et al*., 2019).

2.4 SIGNIFICANCE OF SECTOR-SPECIFIC REITs IN THE ASIA-PACIFIC

Given the vital role of Asia-Pacific REITs in the international REIT investment space, the availability of REIT sub-sectors has been established to accurately capture the status of each property sector, including different asset durability, investment lags, supply or demand elasticities, lease structures and the use of credit to finance development from one and the others. The following sections profile the REIT sub-sectors in the Asia-Pacific context at a country level.

2.4.1 Overview of Asia-Pacific REIT Sub-sectors

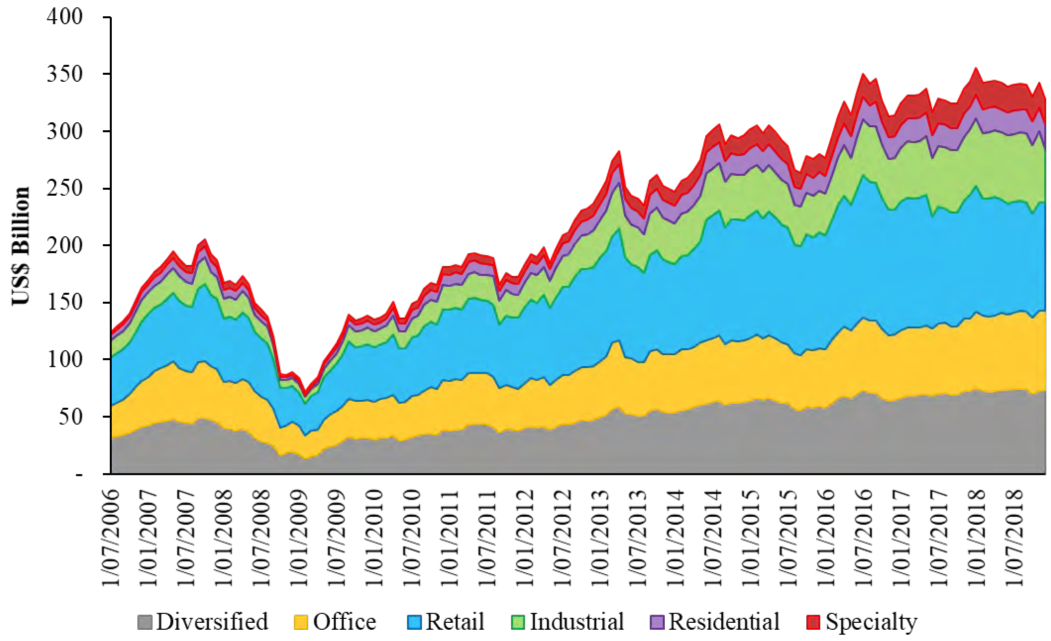
The GICS categorises different property types of REITs into a REIT sub-sector series, which are followed by a number of the leading index providers, such as S&P, Morgan Stanley Capital International (MSCI), Thomson Reuters Eikon and NAREIT. **Table 2-10** lists the GICS REIT sub-sector definitions. As the hotel and health care REIT data series are too thin for analysis in the Asia-Pacific, the following sections and chapters will include hotel and health care REITs in the specialty REIT category. **Figure 2-9** portrays growth in market capitalisation of Asia-Pacific REIT sub-sectors from July 2006 to December 2018. The most vigorous growth in market capitalisation was in specialty REITs, with an 8.8 times increase since 2006 – from US$2.4 billion in July 2006 to US$21.6 billion in December 2018. They were followed by residential (4.7 times increase), industrial (3.2), office (2.5), diversified (2.3) and retail REITs (2.2). As a proportion of the market, however, retail REITs averagely accounted for 34.1% of the total assets of Asia-Pacific REITs over the last 12 years, followed by diversified (21.8%), office (21.7%), industrial (12.8%), residential (5.3%) and specialty REITs (4.3%).

Table 2-10: Definitions of REIT sub-sectors by the GICS

REIT sub-sectors	Definitions
Office	Own and manage office properties and rent space in skyscrapers and office parks to tenants.
Retail	Own and manage retail properties and rent space in large regional malls, outlet centres and shopping centres to tenants.
Industrial	Own and manage industrial facilities and rent space in warehouses and distribution centres to tenants.
Residential	Own and manage various forms of residences and rent space in apartment buildings, student housing, manufactured homes and single-family homes to tenants.
Hotel	Own and manage hotels and resorts and rent space in service and amenities of hotel properties to guests.
Health care	Own and manage a variety of healthcare-related properties and collect rent from tenants. These property types include senior living facilities, hospitals, medical offices and nursing facilities.
Specialty	Own and manage a unique mix of property types, such as movie theatres, casinos, farmland and outdoor advertising sites.
Diversified	Own and manage a mix of property types and collect rent from tenants.

Source: Author's compilation from MSCI (2018) and NAREIT's website

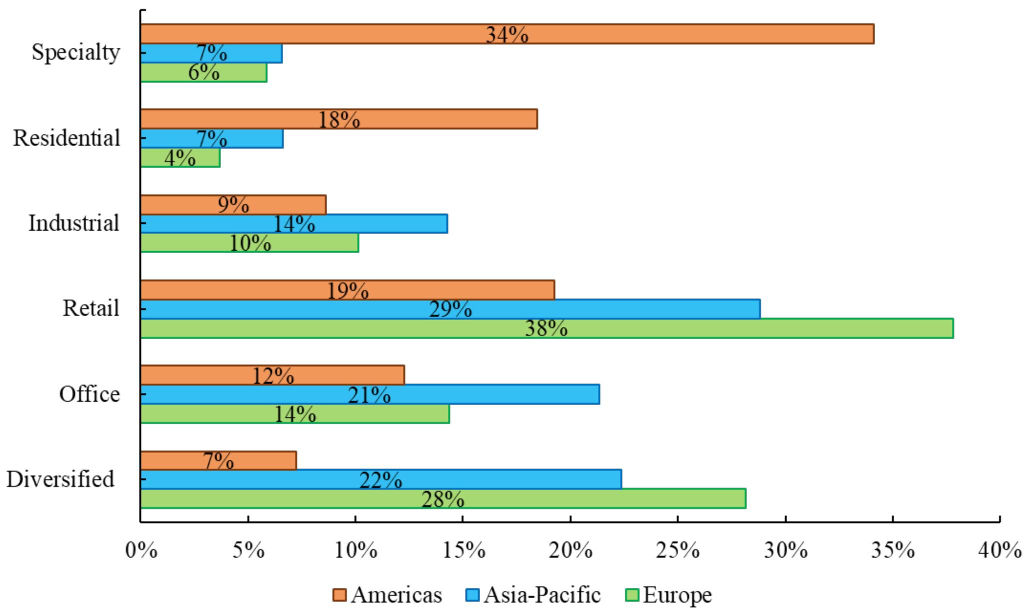
Figure 2-9: Growth in market capitalisation for Asia-Pacific REIT sub-sectors: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

To compare the differences in REIT sub-sectors across the Asia-Pacific, the Americas and Europe, **Figure 2-10** exhibits the breakdown of global REIT sub-sectors by market capitalisation in 2018. Compared with the American REIT markets, the Asia-Pacific was more concentrated on retail (No. 1 in the Asia-Pacific; 29% of the size of Asia-Pacific REITs), diversified (No. 3; 22%) and office (No. 2; 21%) REITs. Similar market trends were witnessed in Europe. However, the Americas had a higher proportion of specialty REITs, a trend not seen in the Asia-Pacific and Europe. It is noteworthy that the Asia-Pacific had a higher ratio of industrial REITs to composite REITs by market capitalisation compared to other regional REIT markets. Considerable Asia-Pacific REIT investment attention has focused on the traditional REIT sector, namely office, retail, industrial and residential REITs. On the other hand, the Americas absorbed a higher level of investment in the non-traditional REIT sector, such as specialty REITs.

Figure 2-10: Breakdown of global REIT sub-sectors by market cap: 2018



Source: Author's compilation/analysis from NAREIT (2018), Thomson Reuters Eikon and the constructed database

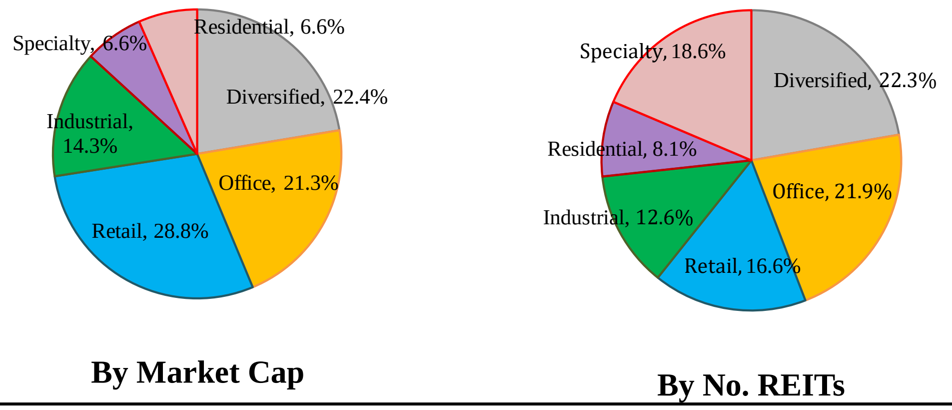
As of December 2018, retail REITs was the largest REIT sub-sector by market capitalisation in the Asia-Pacific, accounting for US$94.5 billion with 41 REITs and contributing 28.8% of the size of Asia-Pacific REITs, as reported in **Table 2-11** and **Figure 2-11**. The second-largest REIT sub-sector was diversified REITs (22.4% of the size of Asia-Pacific REITs), which had total assets of US$73.4 billion, and the largest number of equities at 55. These two REIT sub-sectors were followed by office (No. 3 in the Asia-Pacific; 21.3%; US$69.9B; 54 REITs), industrial (No. 4; 14.3%; US$46.8B; 31), residential (No. 5; 6.6%; US$21.7B; 20) and specialty REITs (No. 6; 6.6%; US$21.6B; 46).

Table 2-11: Profiles of Asia-Pacific REIT sub-sectors: December 2018

REIT sub-sectors	Market cap (US$B)	No. of REITs
Office	69.9	54
Retail	94.5	41
Industrial	46.8	31
Residential	21.7	20
Specialty	21.6	46
Diversified	73.4	55
Total	327.8	247

Source: Author's compilation/analysis constructed database

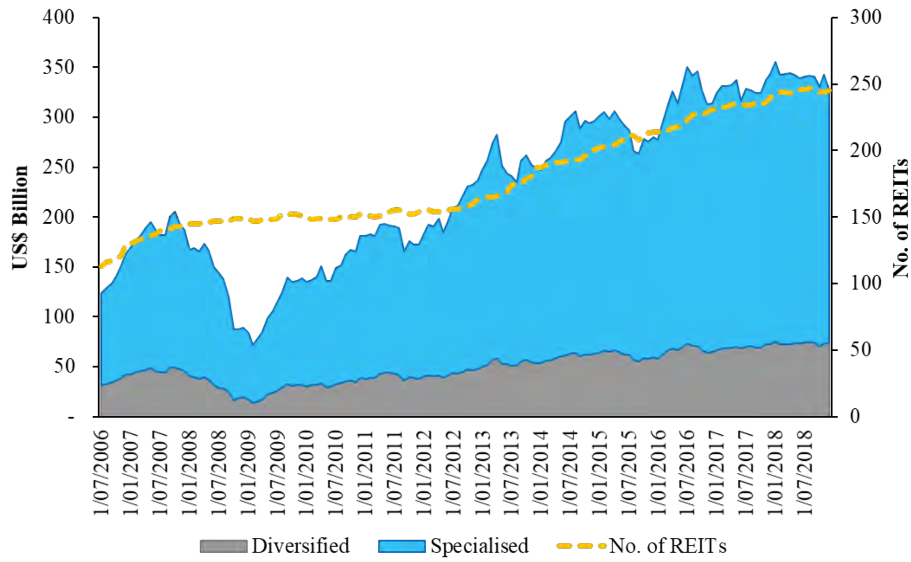
Figure 2-11: Breakdown of Asia-Pacific REIT sub-sectors by market cap and numbers of REITs: December 2018



Source: Author's compilation/analysis from the constructed database

One of the prominent attributes of Asia-Pacific REITs is that sector-specific REITs (e.g. Link REIT (retail), Goodman (industrial), Nippon Building Fund (office), Rural Funds Group and Asia-Pacific Data Centre Group (specialty)) play a significant role in the Asia-Pacific REIT markets compared with diversified REITs (e.g. Stockland, GPT Group). Of the top 10 Asia-Pacific REITs, eight are sector-specific REITs, as documented in **Table 2-8**. **Figure 2-12** shows that sector-specific REITs averagely occupied 78.2% of the total assets of Asia-Pacific REITs over the last 12 years, growing 2.7-fold since July 2006. Clearly, this has seen sector-specific REITs assume a prevailing role in the Asia-Pacific REIT markets compared with their diversified counterparts over the last 12 years.

Figure 2-12: Growth in market capitalisation for sector-specific REITs in the Asia-Pacific: specialised versus diversified: July 2006–December 2018

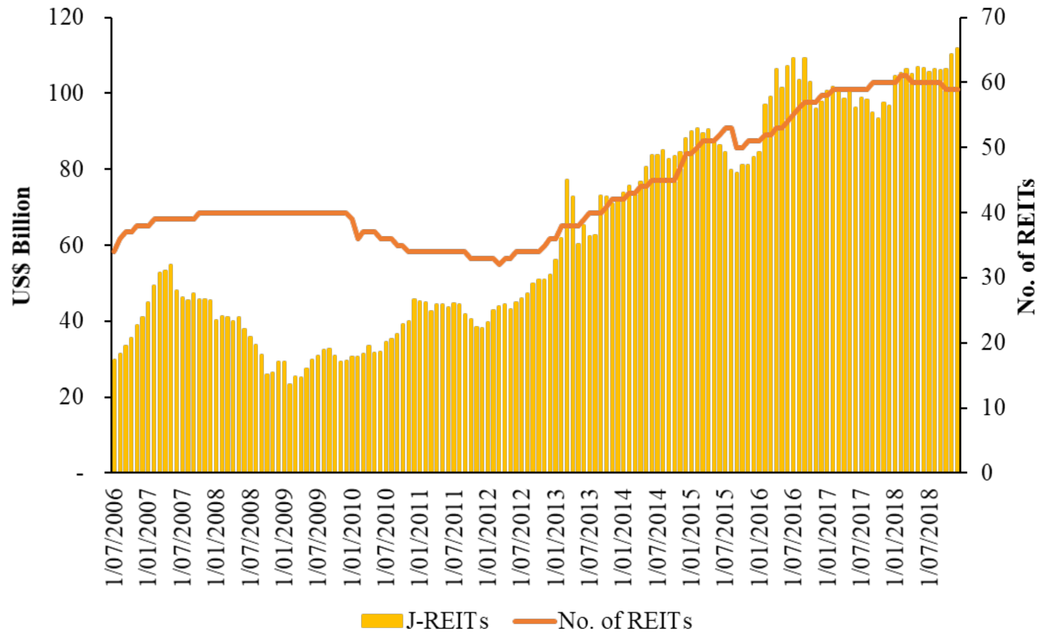


Source: Author's compilation/analysis from the constructed database

2.4.2 Japan

As of December 2018, J-REITs was the largest REIT market in the Asia-Pacific region. With an increase of 3.7 since July 2006, J-REITs grew from US$29.8 billion in July 2006 to US$111.8 billion in December 2018, with 59 REIT equities, as reported in **Figure 2-13**. **Table 2-12** profiles J-REITs in 2018; J-REITs comprised a broad range of REIT sub-sectors, namely office, retail, industrial, residential, specialty and diversified REITs. At a single REIT sub-sector level, **Figure 2-14** graphs growth in market capitalisation of J-REIT sub-sectors from July 2006 to December 2018. Among all REIT sub-sectors, industrial REITs had the strongest growth due to the recent e-commerce trend (Lin *et al.*, 2020), with increasing by 18.2 since July 2006. This sector was followed by residential (8.0), specialty (5.3), diversified (3.4), retail (3.3) and office REITs (2.5). To detail the profiles of J-REIT sub-sectors, **Table 2-14** and **Figure 2-15** present market capitalisation and numbers of REITs for each J-REIT sub-sector in 2018. Office REITs was the largest REIT sub-sector by market capitalisation, with US$35.5 billion and 13 REIT firms. It contributed 31.8% of the total assets of J-REITs, tracked by diversified (No. 2 in the J-REIT market; 25.3% of J-REITs; US$28.3B; 18 REITs), residential (No. 3; 15.7%; US$17.5B; 9), industrial (No. 4; 13.2%; US$14.7B; 8), retail (No. 5; 9.3%; US$10.4B; 4) and specialty REITs (No. 6; 4.7%; US$5.3B; 7).

Figure 2-13: Growth in market capitalisation for J-REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

Table 2-12: Profiles of J-REITs: December 2018

	REITs	Market cap (US$M)	Property type*
1	Nippon Building Fund	8,893.0	Office
2	Japan Real Estate Investment	7,777.3	Office
3	Japan Retail Fund	5,237.7	Retail
4	United Urban Investment	4,739.3	Diversified
5	Nippon Prologis REIT	4,620.4	Industrial
6	Orix JREIT	4,588.5	Diversified
7	Daiwa House REIT	4,315.4	Residential
8	GLP J-REIT	3,909.8	Industrial
9	Advance Residence	3,722.1	Residential
10	Japan Prime Realty	3,508.1	Office
11	Activia Properties	3,103.5	Diversified
12	Daiwa Office	3,097.9	Office
13	Japan Hotel REIT	2,866.1	Specialty
14	Kenedix Office	2,734.0	Office
15	Sekisui House REIT	2,407.1	Residential
16	Mori Hills REIT	2,360.0	Office
17	Nippon Accommodations Fund	2,340.6	Residential
18	Invincible Investment	2,334.6	Diversified
19	Aeon REIT	2,047.6	Retail
20	Frontier REIT	1,966.6	Retail
21	Hulic REIT	1,942.9	Diversified
	Total	111,779.6	

Note: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

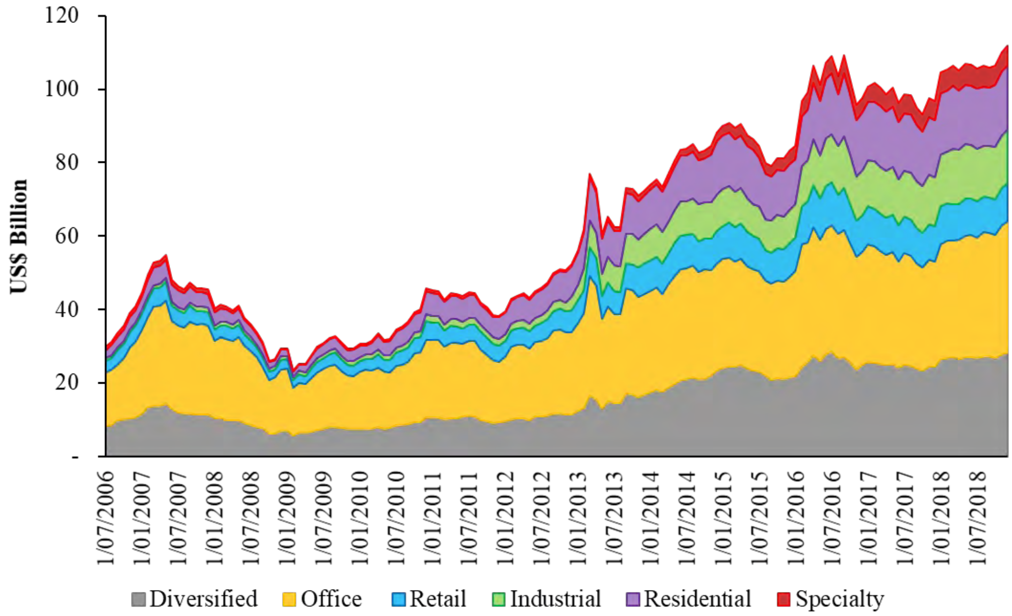
Table 2-13: Profiles of J-REITs: December 2018 (Cont1)

	REITs	Market cap (US$M)	Property type*
22	Mori Trust Sogo REIT	1,920.2	Diversified
23	Japan Logistics Fund	1,856.1	Industrial
24	Japan Excellent	1,764.9	Office
25	Industrial & Infrastructure Fund	1,762.1	Industrial
26	Premier Investment	1,499.3	Diversified
27	Comforia Residential REIT	1,495.9	Residential
28	Tokyu REIT	1,466.6	Diversified
29	Ichigo Office Real Estate Investment	1,351.9	Office
30	Mcubs Midcity REIT	1,299.9	Office
31	Nippon REIT	1,299.7	Diversified
32	Japan Rental Housing	1,227.3	Residential
33	Fukuoka REIT	1,208.7	Diversified
34	Invesco Office J-REIT	1,208.5	Office
35	Kenedix Residential	1,193.9	Residential
36	Kenedix Retail REIT	1,152.2	Retail
37	Heiwa Real Estate REIT	1,132.2	Diversified
38	LaSalle Logiport REIT	1,063.8	Industrial
39	Hoshino Resorts REIT	1,051.5	Specialty
40	Global One Real Estate Investment	967.9	Office
41	Hankyu REIT	906.1	Diversified
42	Mitsui Fudosan Logistics Park	742.5	Industrial
43	Mirai REIT	663.9	Diversified
44	Mori Trust Hotel REIT	582.4	Specialty
45	One REIT	575.4	Office
46	Mitsubishi Estate Logistics REIT	535.5	Industrial
47	Star Asia Investment REIT	517.6	Diversified
48	Samty Residential REIT	399.7	Residential
49	Starts Proceed Investment	396.7	Residential
50	Ichigo Hotel REIT	316.3	Specialty
51	Tosei REIT	293.8	Diversified
52	Sakura Sogo REIT	243.7	Diversified
53	Xymax REIT	224.0	Diversified
54	CRE Logistics REIT	209.6	Industrial
55	Healthcare and Medical	198.4	Specialty
56	Ooedo Onsen REIT	170.8	Specialty
57	Takara Leben Infrastructure Fund	129.1	Diversified
58	Marimo Regional Revitalization REIT	125.6	Diversified
59	Nippon Healthcare	113.4	Specialty
	Total	111,779.6	

Note: *Categorised by the GICS

Source: Author's compilation from Thomson Reuters Datastream

Figure 2-14: Growth in market capitalisation for J-REIT sub-sectors: July 2006–December 2018



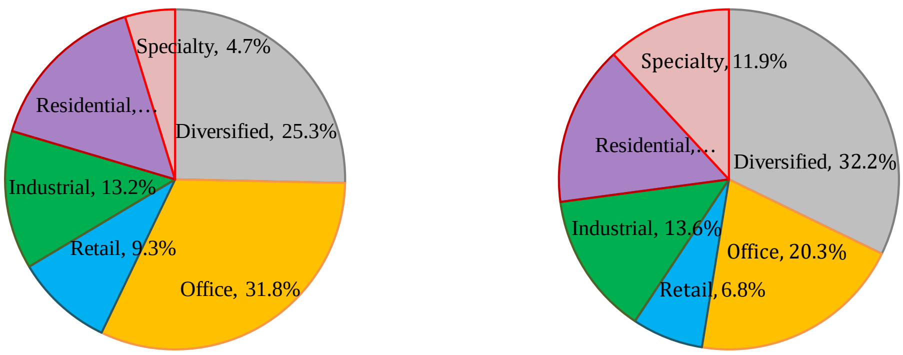
Source: Author's compilation/analysis from the constructed database

Table 2-14: J-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$B)	No. of REITs
Office	35.5	13
Retail	10.4	4
Industrial	14.7	8
Residential	17.5	9
Specialty	5.3	7
Diversified	28.3	18
Total	111.8	59

Source: Author's compilation/analysis from the constructed database

Figure 2-15: Breakdown of J-REITs: December 2018



By Market Cap **By No. REITs**

Source: Author's compilation/analysis from the constructed database

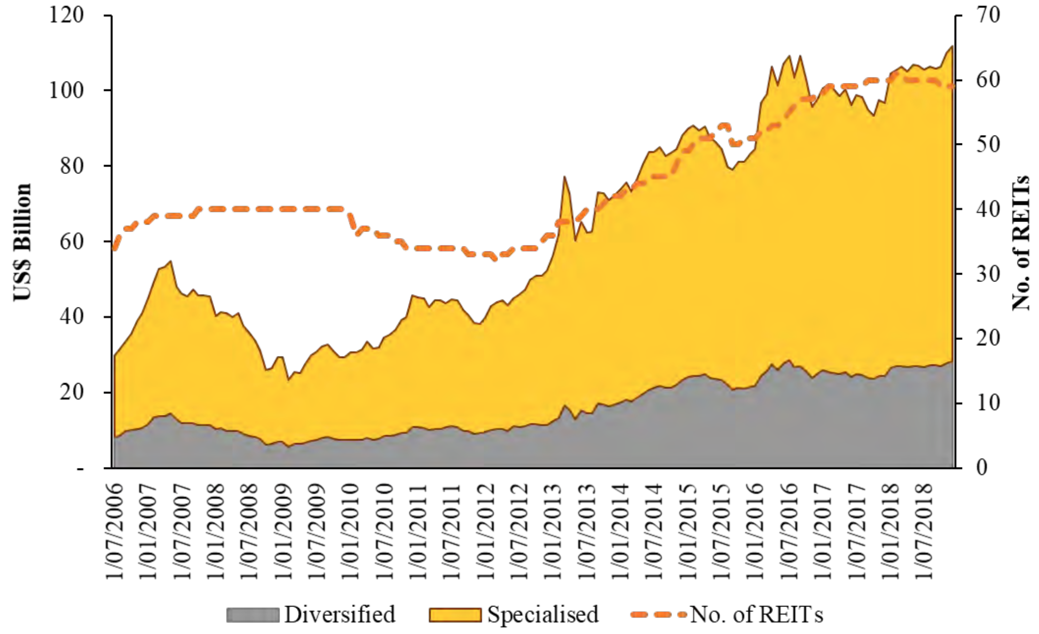
Table 2-15 lists the top 10 J-REITs in 2018. Nippon Building Fund, which is categorised as office REITs, was the largest REIT in the J-REIT market, with the total market capitalisation of US$8.9 billion and 72 office properties. Nippon Prologis REIT was fifth by market capitalisation, with total assets of US$4.6 billion and 42 industrial/logistics properties. Daiwa House REIT was ranked seventh in the J-REIT market and was the largest residential REITs in Japan, accounting for US$4.3 billion with 216 residential properties. Interestingly, eight of the top 10 J-REITs are sector-specific REITs. From the J-REIT sub-sector segment, sector-specific REITs played a prominent role in the J-REIT market compared with diversified REITs over the last 12 years. **Figure 2-16** depicts that sector-specific J-REITs occupied an average of 75.2% of the market capitalisation of J-REITs over the past 12 years, increasing their total assets 3.9-fold since July 2006. The primary role of sector-specific REITs was evident in the J-REIT market from July 2006 to December 2018.

Table 2-15: Profiles of leading J-REITs: December 2018

Rank	REITs	Listed	Property type*	No. of properties	Market cap (US$B)
1	Nippon Building Fund	Sep. 01	Office	72	8.9
2	Japan Real Estate Investment	Sep. 01	Office	72	7.8
3	Japan Retail Fund	Mar. 02	Retail	101	5.2
4	United Urban Investment	Dec. 03	Diversified	120	4.7
5	Nippon Prologis REIT	Feb. 13	Industrial	42	4.6
6	Orix JREIT	Jun. 02	Diversified	111	4.6
7	Daiwa House REIT	Mar. 06	Residential	216	4.3
8	GLP J-REIT	Dec. 12	Industrial	76	3.9
9	Advance Residence	Mar. 10	Residential	264	3.7
10	Japan Prime Realty	Jun. 02	Office	62	3.5

Note: *Categorised by the GICS
Source: Author’s compilation from Thomson Reuters Eikon and various companies’ websites

Figure 2-16: Growth in market capitalisation for sector-specific REITs in Japan: specialised versus diversified: July 2006–December 2018

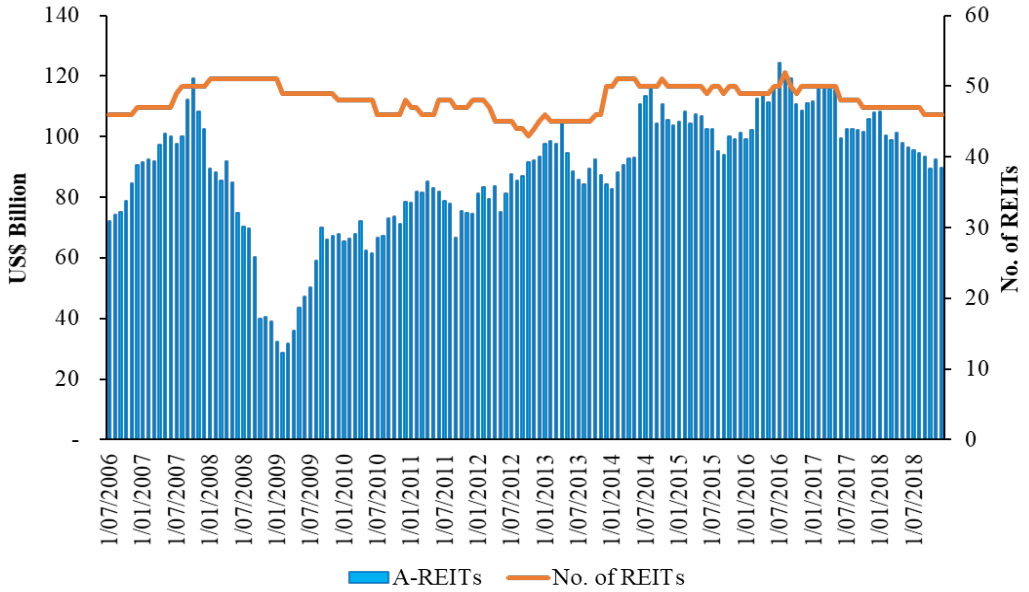


Source: Author's compilation/analysis from the constructed database

2.4.3 Australia

As the second-largest REIT market in the Asia-Pacific, A-REITs introduced REIT legislation and launched the first REIT in 1971. As graphed in **Figure 2-17**, the A-REIT market increased its total assets from US$72.1 billion in July 2006 to US$89.6 billion in December 2018, a 1.2-fold increase. With 46 REITs, A-REITs includes various REIT sub-sectors, namely office, retail, industrial, residential, specialty and diversified REITs, as profiled in **Table 2-16**. **Figure 2-18** displays the dynamics of growth in market capitalisation for A-REIT sub-sectors from July 2006 to December 2018. With the strongest growth, specialty REITs increased in size 5.2-fold since July 2006, followed by industrial (1.6), office (1.5), diversified (1.3), retail (1.0) and residential REITs (0.4). **Table 2-18** and **Figure 2-19** tabulate the A-REIT sub-sectors as of December 2018. Retail (US$31.9B) was the largest REIT sub-sector in A-REITs, despite having the slowest growth by market capitalisation over the past 12 years. It represented 35.6% of total A-REITs, with 11 REIT firms, followed by diversified REITs (No. 2 in A-REITs, 28.2% of A-REITs, US$25.2B; 10 REITs), industrial (No. 3; 16.6%; US$14.9B; 4), office (No. 4; 14.7%; US$13.2B; 9), specialty (No. 5; 3.9%; US$3.5B; 10) and residential REITs (No.6; 0.9%; US$0.8B, 2).

Figure 2-17: Growth in market capitalisation for J-REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

Table 2-16: Profiles of A-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	Scentre Group	14,598.3	Retail
2	Goodman	13,574.2	Industrial
3	Dexus	7,605.0	Office
4	Vicinity Centres	7,021.7	Retail
5	GPT Group	6,785.2	Diversified
6	Stockland	5,961.4	Diversified
7	Mirvac	5,768.8	Diversified
8	Unibail-Rodamco-Westfield	3,171.9	Retail
9	Charter Hall Group	2,433.1	Diversified
10	Investa Office Fund	2,350.8	Office
11	Growthpoint Properties Australia	1,916.1	Diversified
12	Shopping Centres Australasia Property Group	1,642.6	Retail
13	BWP Trust	1,596.4	Retail
14	Cromwell Property Group	1,552.2	Office
15	Abacus Property Group	1,334.7	Diversified
16	Charter Hall Retail REIT	1,269.4	Retail
17	Viva Energy REIT	1,149.6	Retail
18	Charter Hall Long Wale REIT	845.8	Diversified
19	National Storage REIT	825.9	Specialty
20	Aventus Retail Property Fund	796.3	Retail
21	ALE Property Group	671.2	Specialty
	Total	89,626.2	

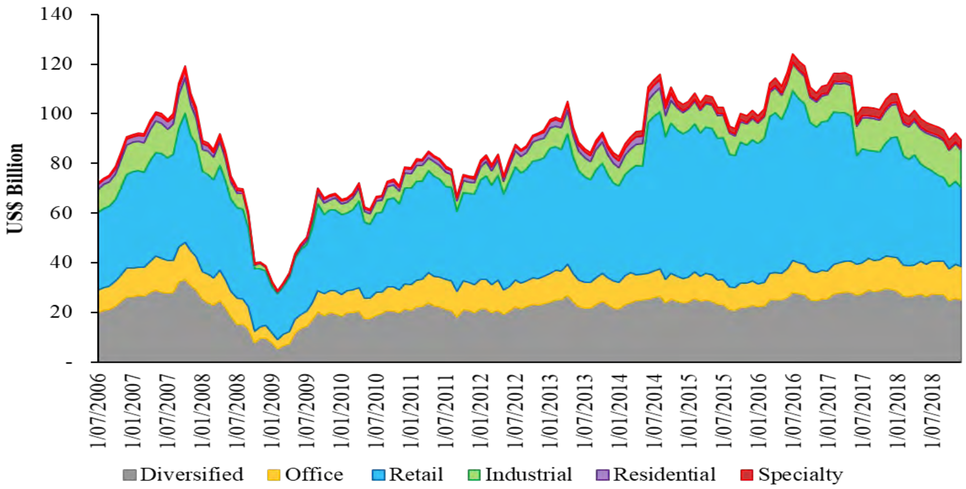
Note: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Table 2-17: Profiles of A-REITs: December 2018 (Cont1)

	REITs	Market cap (US$ M)	Property type*
22	Centuria Metropolitan REIT	594.5	Office
23	Charter Hall Education Trust	536.6	Specialty
24	Centuria Industrial REIT	514.6	Industrial
25	GDI Property Group	512.9	Office
26	Rural Funds Group	501.9	Specialty
27	Ingenia Communities Group	490.4	Residential
28	Propertylink Group	485.9	Industrial
29	Arena REIT	460.3	Specialty
30	Carindale Property Trust	354.3	Retail
31	US Masters Residential Property Fund	350.3	Residential
32	Hotel Property Investments	327.1	Specialty
33	Industria REIT	313.0	Industrial
34	Australian Unity Office Fund	309.5	Office
35	Convenience Retail REIT	224.1	Retail
36	360 Capital Group	170.7	Office
37	Asia-Pacific Data Centre Group	157.1	Specialty
38	Garda Diversified Property Fund	147.2	Office
39	Elanor Retail Property Fund	113.3	Retail
40	Blackwall Property Trust	70.4	Diversified
41	Aspen Group	65.4	Diversified
42	Aims Property Securities Fund	49.3	Diversified
43	Agricultural Land Trust	2.9	Specialty
44	Ante Real Estate Trust	1.6	Diversified
45	Lantern Hotel Group	1.2	Specialty
46	RNY Property Trust	1.1	Office
	Total	89, 626.2	

Note: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-18: Growth in market capitalisation for A-REIT sub-sectors: July 2006–December 2018



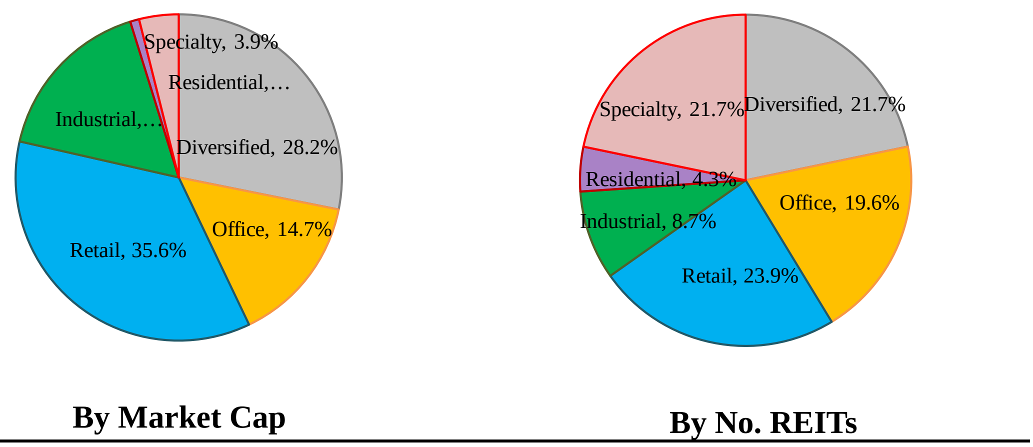
Source: Author's compilation/analysis from the constructed database

Table 2-18: A-REIT by property types: December 2018

REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	13.2	9
Retail	31.9	11
Industrial	14.9	4
Residential	0.8	2
Specialty	3.5	10
Diversified	25.2	10
Total	89.6	46

Source: Author's compilation from constructed database

Figure 2-19: Breakdown of A-REITs: December 2018



Source: Author's compilation from constructed database

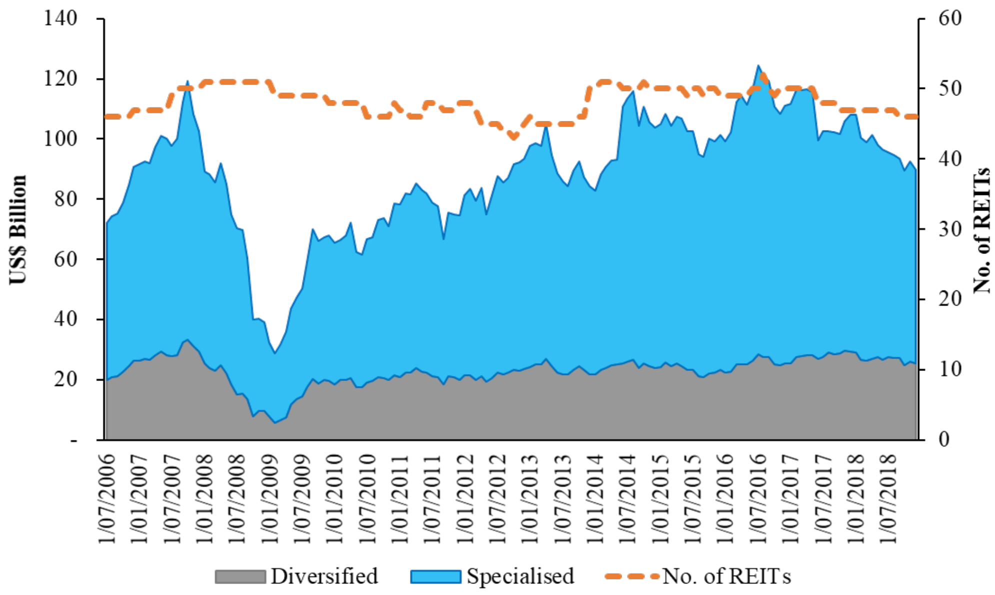
The REIT sub-sector segment has seen the strongest role of sector-specific REITs in the Australian REIT market. To underpin the status of sector-specific A-REITs, **Table 2-19** lists the top 10 A-REITs by market capitalisation in December 2018. Scentre Group was the largest REIT in the Australian REIT context and the thirteenth largest REIT at a global level, accounting for US$14.6 billion, with 41 retail properties. Goodman, ranked fourteenth in the international context, was the second-largest REIT in the A-REIT market, with total assets of US$13.6 billion and 270 industrial/logistics properties. An interesting finding from the table is that seven out of 10 leading Australian REITs are sector-specific REITs. Only three are diversified REITs, namely GPT (No. 5 in A-REITs; US$6.8B; 67 properties), Stockland (No.6; US$6.0B; 198) and Mirvac (No. 7; US$5.8B; 46). It should also be noted that Westfield was sold to Unibail-Rodamco SE for US$24.7 billion in December 2017 (RCA, 2018a). To detail the primary role of sector-specific REITs in the Australian REIT market, **Figure 2-20** highlights that sector-specific REITs have averagely represented 74.1% of the A-REIT market over the last 12 years, a 1.2-fold increase since July 2006. The prominent role of sector-specific REITs has been evidenced in the Australian REIT market from July 2006 to December 2018.

Table 2-19: Profiles of leading A-REITs: December 2018

Rank	REITs	Listed	Property type*	No. of properties	Market cap (US$ B)
1	Scentre Group	Jun. 2014	Retail	41	14.6
2	Goodman	Jun. 1987	Industrial	270	13.6
3	Dexus	Oct. 2004	Office	155	7.6
4	Vicinity Centres	Dec. 2011	Retail	66	7.0
5	GPT	Apr. 1971	Diversified	67	6.8
6	Stockland	Oct. 1982	Diversified	198	6.0
7	Mirvac	Jun. 1999	Diversified	46	5.8
8	Unibail-Rodamco-Westfield	Jan. 1975	Retail	159	3.2
9	Charter Hall Group	Nov. 1996	Diversified	59	2.4
10	Investa Office Fund	Feb. 1992	Office	36	2.4

Note: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Eikon and various companies' websites

Figure 2-20: Growth in market capitalisation for sector-specific REITs in Australia: specialised versus diversified: July 2006–December 2018

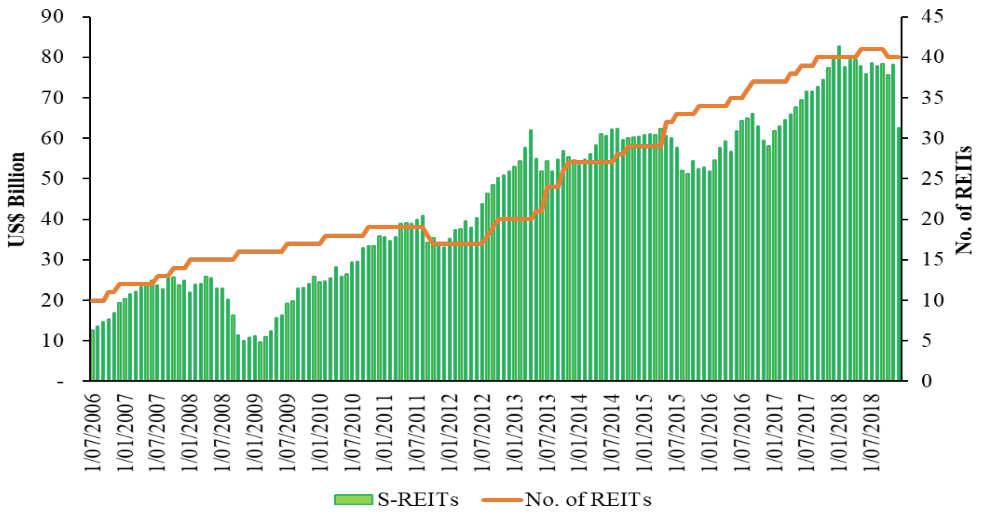


Source: Author's compilation/analysis from the constructed database

2.4.4 Singapore

As of December 2018, S-REITs was the third-largest REIT market by market capitalisation in the Asia-Pacific region. **Figure 2-21** displays the dynamics of growth in market capitalisation for S-REITs from July 2006 to December 2018. With a 4.9-fold increase since July 2006, S-REITs have increased from US$12.7 billion in July 2006 to US$62.6 billion in December 2018. **Table 2-18** shows that there were 40 REITs in the S-REIT market as of December 2018, including office, retail, industrial, residential, specialty and diversified REITs. As displayed in **Figure 2-22**, specialty REITs had the most vigorous growth in market capitalisation over the last 12 years, increasing total assets from US$0.4 billion in July 2006 to US$8.1 billion in December 2018, increasing 20.2 times since July 2006. Its growth was faster than that of residential (7.9 times), diversified (7.5), retail (5.2), office (3.9) and industrial REITs (3.2).

Figure 2-21: Growth in market capitalisation for S-REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

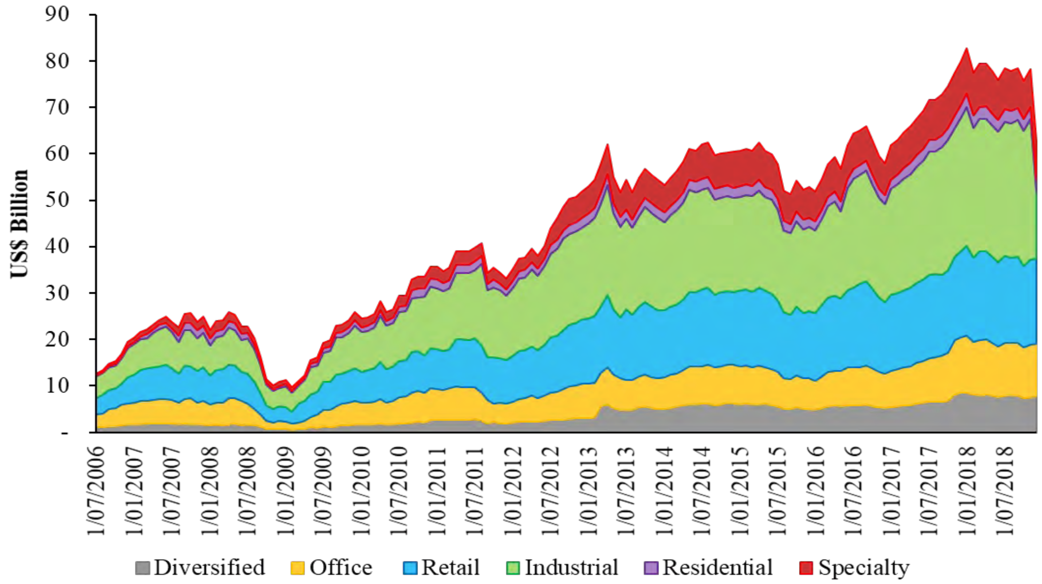
Table 2-19 and **Figure 2-23** articulate the REIT sub-sectors in the S-REIT market. Retail REITs accounted for US$18.5 billion and contributed 29.5% of the total assets of S-REITs, being the largest REIT sub-sector in the S-REIT market, with 10 REIT equities. It was followed by industrial (No. 2 in S-REITs; 23.2% of S-REITs; US$14.5B; 8 REITs), office (No. 3; 12.3%; US$11.3B; 7), specialty (No. 4; 13.0%; US$8.1B; 9), diversified (No. 5; 12.3%; US$7.7B; 4) and residential REITs (No. 6; 4.1%; US$2.5B; 2).

Table 2-18: Profiles of S-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	Capitaland Mall Trust	6,113.2	Retail
2	Ascendas REIT	5,865.0	Industrial
3	CapitaLand Commercial Trust	4,807.5	Office
4	Mapletree Commercial Trust	3,496.6	Retail
5	Suntec REIT	3,487.6	Diversified
6	Mapletree Logistics Trust	3,318.7	Industrial
7	Keppel REIT	2,838.2	Office
8	Mapletree North Asia Commercial Trust	2,648.4	Diversified
9	Fortune REIT	2,190.0	Retail
10	SPH REIT	1,894.5	Retail
11	Ascott Residence Trust	1,715.1	Residential
12	Frasers Logistics & Industrial Trust	1,528.1	Industrial
13	Frasers Centrepoint Trust	1,476.9	Retail
14	Keppel DC REIT	1,338.7	Specialty
15	CDL Hospitality REIT Units	1,291.2	Specialty
16	ESR-REIT	1,186.2	Industrial
17	Parkway Life REIT	1,167.4	Specialty
18	Cromwell European REIT	1,097.5	Diversified
19	Starhill Global Real Estate Investment	1,088.2	Retail
20	Manulife US REIT	982.8	Office
21	CapitaLand Retail China Trust	978.4	Retail
22	Frasers Hospitality Trust	968.4	Specialty
23	Oue Commercial REIT	963.9	Office
24	Frasers Commercial Trust	900.6	Office
25	OUE Hospitality Trust	894.9	Specialty
26	Far East Hospitality Trust	830.9	Specialty
27	Ascendas India Trust	822.6	Residential
28	AIMS AMP Capital Industrial REIT	670.5	Industrial
29	Ascendas Hospitality Trust	640.5	Specialty
30	First REIT	569.8	Specialty
31	Sasseur REIT	562.9	Retail
32	Cache Logistics Trust	548.0	Industrial
33	Keppel-KBS US REIT	501.3	Office
34	Soilbuild Business Space REIT	451.4	Diversified
35	RHT Health Trust	435.5	Specialty
36	EC World REIT	400.9	Industrial
37	Lippo Malls Indonesia Retail Trust	381.9	Retail
38	IREIT Global	336.2	Office
39	Sabana Shariah Compliant Industrial REIT	331.4	Industrial
40	BHG Retail REIT	264.3	Retail
	Total	62,603.1	

Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-22: Growth in market capitalisation for S-REIT sub-sectors: July 2006–December 2018



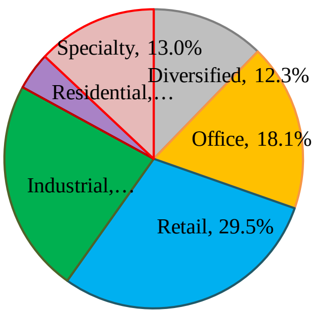
Source: Author's compilation/analysis from the constructed database

Table 2-19: S-REITs by property types: December 2018

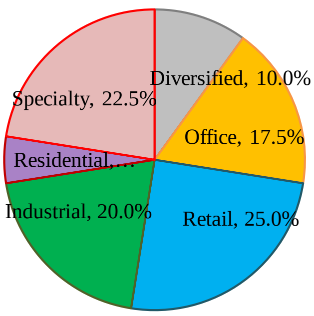
REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	11.3	7
Retail	18.5	10
Industrial	14.5	8
Residential	2.5	2
Specialty	8.1	9
Diversified	7.7	4
Total	62.6	40

Source: Author's compilation/analysis from the constructed database

Figure 2-23: Breakdown of S-REITs: December 2018



By Market Cap



By No. REITs

Source: Author's compilation/analysis from the constructed database

Sector-specific REITs played a more significant role than their diversified counterparts. To reinforce the significant status of sector-specific REITs, **Table 2-20** presents the profiles of leading S-REITs in December 2018. With the total assets of US$6.1 billion, Capitaland Mall Trust was the largest REIT sub-sector in the S-REIT market, owning 16 retail properties. With 171 industrial/logistics properties, Ascendas REIT was ranked second, accounting for US$5.9 billion. Of the top 10 S-REITs, eight are sector-specific REITs, including Capitaland Mall Trust, Ascendas REIT, Capitaland Commercial Trust (No. 3; US$4.8B; office), Mapletree Commercial Trust (No. 4; US$3.5B; retail), Mapletree Logistics Trust (No. 6; US$3.3B; industrial), Keppel REIT (No. 7; US$2.8B; office), Fortune REIT (No. 9; US$2.2B; retail) and SPH REIT (No. 10; US$1.9B; retail). Only two are diversified REITs, namely Suntec REIT (No. 5; US$3.5B) and Mapletree North Asia (No. 8; US$2.6B).

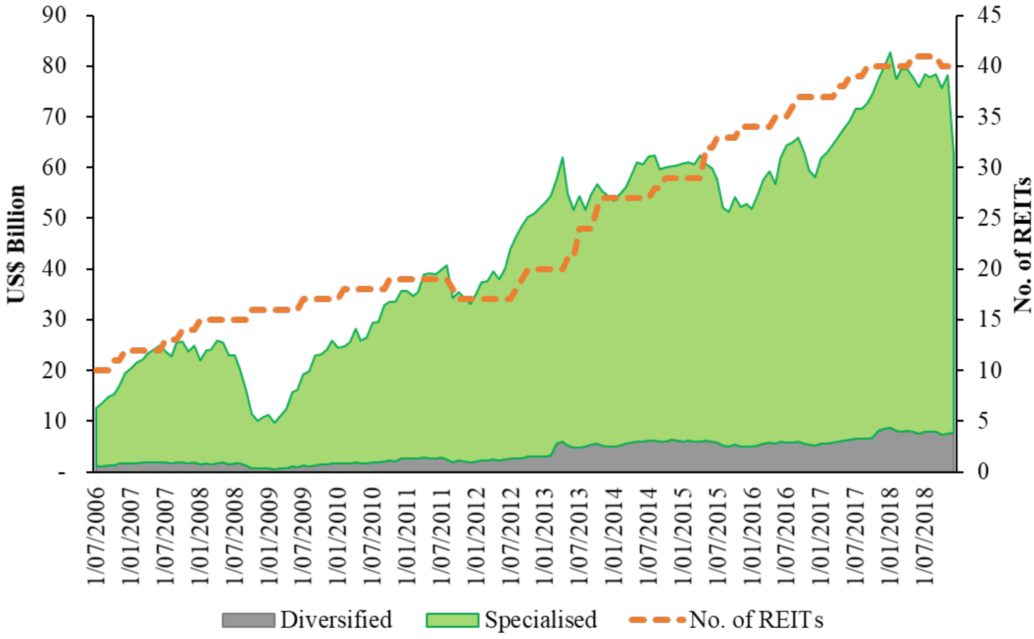
Figure 2-24 shows that sector-specific REITs have dominated the S-REIT market, contributing an average 91.9% of a market capitalisation of S-REITs over the last 12 years. Meanwhile, the growth of sector-specific REITs (4.7 times since July 2006) was not comparable with that of diversified REITs (7.5). This has seen sector-specific REITs emerging as the major segment in the S-REIT market from July 2006 to December 2018.

Table 2-20: Profiles of leading S-REITs: December 2018

Rank	REITs	Listed	Property type	No. of properties	Market cap (US$ B)
1	Capitaland Mall Trust	Jul. 02	Retail	16	6.1
2	Ascendas REIT	Nov. 02	Industrial	171	5.9
3	Capitaland Commercial Trust	May 04	Office	10	4.8
4	Mapletree Commercial Trust	Apr. 11	Retail	5	3.5
5	Suntec REIT	Dec. 04	Diversified	7	3.5
6	Mapletree Logistics Trust	Jul. 05	Industrial	125	3.3
7	Keppel REIT	Apr. 06	Office	9	2.8
8	Mapletree North Asia Commercial Trust	Mar. 13	Diversified	9	2.6
9	Fortune REIT	Jul. 03	Retail	16	2.2
10	SPH REIT	Jul. 13	Retail	4	1.9

Source: Author’s compilation from Thomson Reuters Eikon and various companies’ websites

Figure 2-24: Growth in market capitalisation for sector-specific REITs in Singapore: specialised versus diversified: July 2006–December 2018



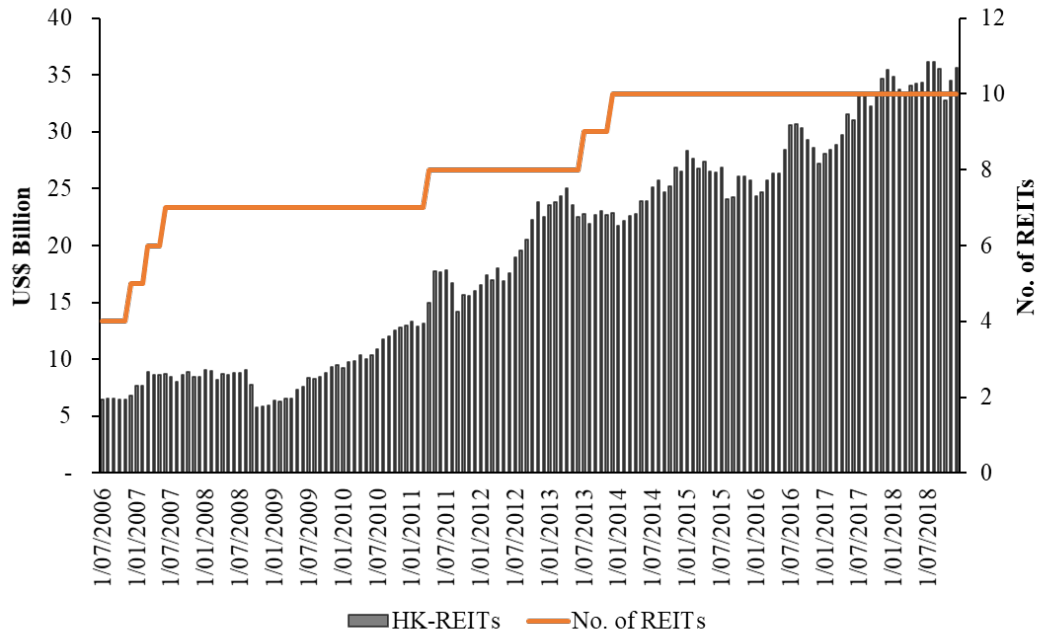
Source: Author's compilation/analysis from the constructed database

2.4.5 Hong Kong

As of December 2018, Hong Kong REITs (HK-REITs) was the fourth largest REIT market in the Asia-Pacific region. Increasing by 5.5 since July 2006, HK-REITs has increased from US$6.5 billion in July 2006 to US$35.6 billion at the end of 2018, as documented in **Figure 2-25**. **Table 2-21** lists 40 REIT equities in Hong Kong as of December 2018. These 10 REITs comprise office, retail, specialty and diversified REITs. Unlike REITs in Japan, Australia and Singapore, pure industrial and residential REITs did not exist in the HK-REIT market. **Figure 2-26** portrays the dynamics of growth in market capitalisation of these four REIT sub-sectors in the HK-REIT market from July 2006 to December 2018. With a 15.1-fold increase since July 2006, diversified REITs grew faster than the other REIT sub-sectors, including retail (5.3), office (3.2) and specialty REITs (1.1). **Table 2-22** and **Figure 2-27** illustrate that retail REITs was the largest REIT sub-sector in HK-REITs, with total assets of US$23.6 billion and 2 REIT equities, contributing 66.5% of HK-REITs. It was followed by diversified REITs (No. 2 in HK-REITs; 16.1% of HK-REITs; US$5.7B; 3 REITs), office (No. 3; 14.4%; US$5.1B; 3) and specialty REITs (No. 4; 3.1%; US$1.1B; 2).

The most substantial contributor by market capitalisation was sector-specific REITs. Seven of 10 HK-REITs are sector-specific REITs, such as Link REIT (No. 1; US$21.4B; retail), Champion REIT (No. 2; US$4.0B; office), Fortune REIT (No. 4; US$2.2B; retail), Regal REIT (No. 7; US$0.9B; specialty), Prosperity REIT (No. 8; US$0.6B; office), Spring REIT (No. 9; US$0.6 B; office) and New Century REIT (No. 10; US$0.2B; specialty) (**Table 2-21**).

Figure 2-25: Growth in market capitalisation for HK-REITs: July 2006–December 2018



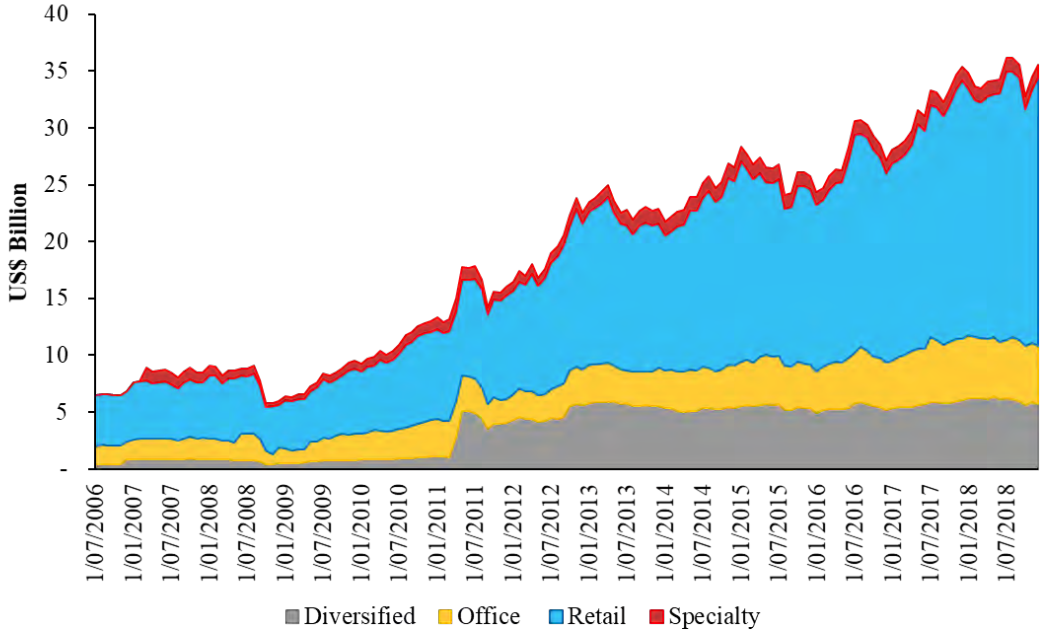
Source: Author's compilation/analysis from the constructed database

Table 2-21: Profiles of HK-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	Link REIT	21,391.4	Retail
2	Champion REIT	4,002.9	Office
3	Hui Xian REIT	2,675.0	Diversified
4	Fortune REIT	2,209.7	Retail
5	Yuexiu REIT	1,991.8	Diversified
6	Sunlight REIT	1,056.1	Diversified
7	Regal REIT	927.8	Specialty
8	Prosperity REIT	569.3	Office
9	Spring REIT	562.3	Office
10	New Century REIT	211.4	Specialty
	Total	35,597.8	

Note: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-26: Growth in market capitalisation for HK-REIT sub-sectors: July 2006–December 2018



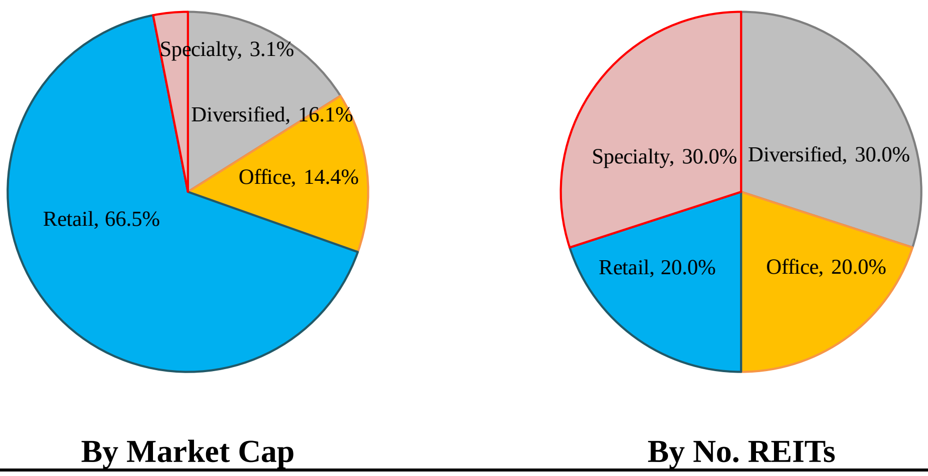
Source: Author's compilation/analysis from the constructed database

Table 2-22: HK-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	5.1	3
Retail	23.6	2
Specialty	1.1	2
Diversified	5.7	3
Total	35.6	10

Source: Author's compilation from constructed database

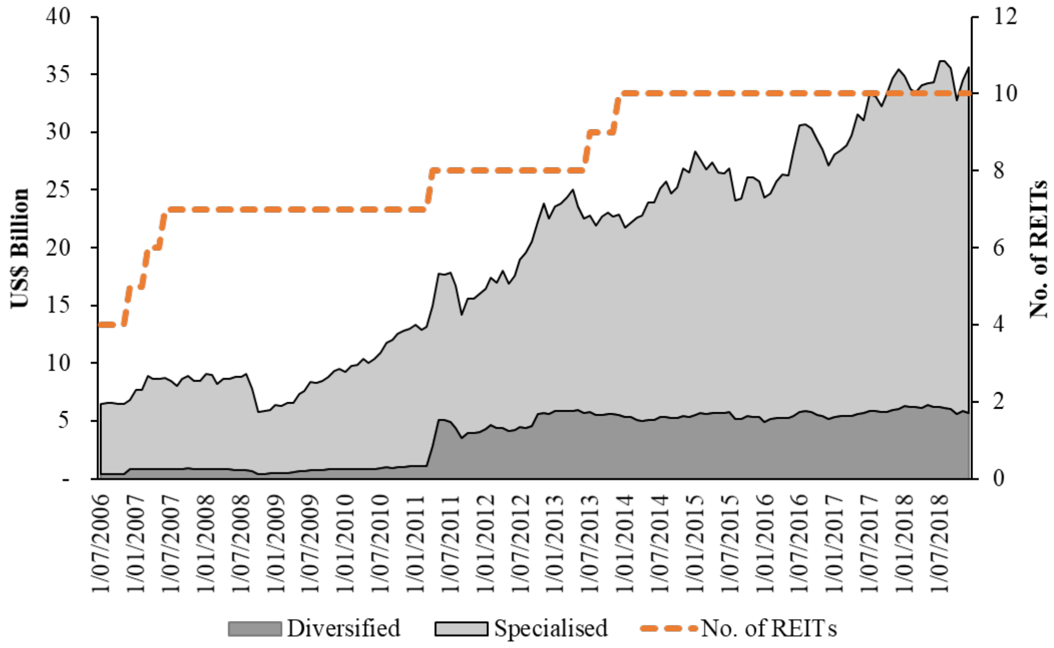
Figure 2-27: Breakdown of HK-REITs: December 2018



Source: Author's compilation from the constructed database

The influential role of sector-specific REITs in HK-REITs can be observed in **Figure 2-28**, which shows that sector-specific REITs have averagely contributed 83.5% of HK-REITs over the past 12 years. Over the same time, diversified REITs represented an average of only 16.5% of the total assets of HK-REITs. The prominent role of sector-specific REITs has been evident in the HK-REIT market from July 2006 to December 2018.

Figure 2-28: Growth in market capitalisation for sector-specific REITs in Hong Kong: specialised versus diversified: July 2006–December 2018

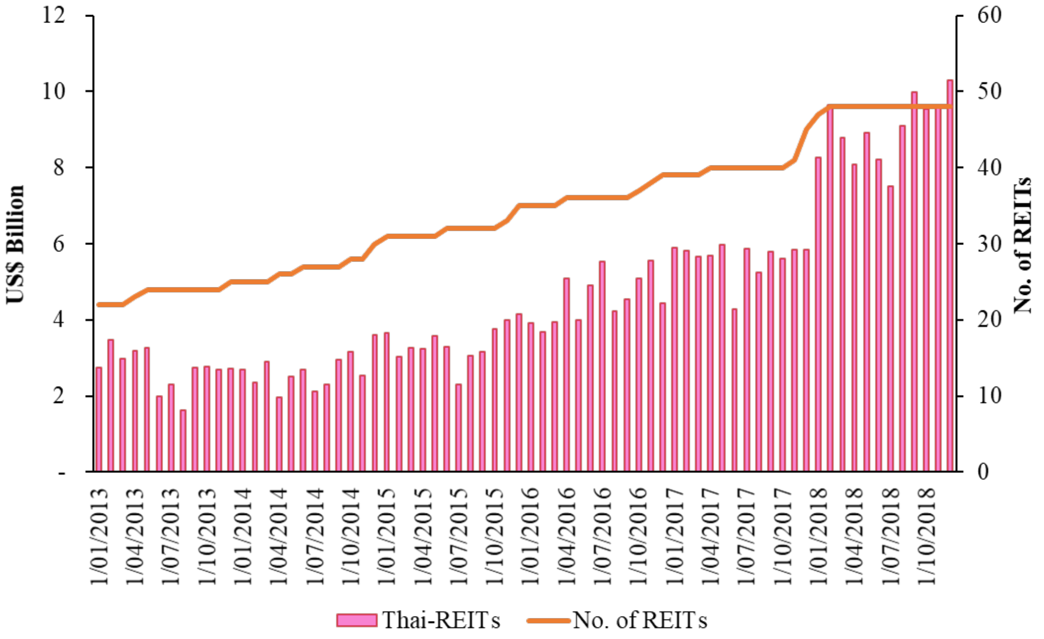


Source: Author's compilation/analysis from the constructed database

2.4.6 Thailand

Introduced in 2013, Thailand REITs (Thai-REITs) was the fifth largest REIT market in the Asia-Pacific region. **Figure 2-29** depicts the dynamic growth in market capitalisation of Thai-REITs from January 2013 to December 2018. It grew from US$2.8 billion in January 2013 to US$10.3 billion at the end of 2018, a 3.7-fold increase since its launch date, with 50 REIT equities as of December 2018. **Table 2-23** tabulates the profiles of Thai-REITs, comprising office, retail, industrial, residential, specialty and diversified REITs. Categorised by REIT sub-sectors, **Figure 2-30** shows that the growth of office REITs (28.5 times) since January 2013 has been faster than that of the other REIT sub-sectors, including industrial (27.9), retail (2.8), specialty (2.4), diversified (1.8) and residential REITs (0.9).

Figure 2-29: Growth in market capitalisation for Thai-REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

Table 2-23: Profiles of Thai-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	CPN Retail Growth Leasehold REIT	1,732.7	Retail
2	Tesco Lotus Retail Growth Freehold and Leasehold Property Fund	1,416.1	Retail
3	TICON Freehold and Leasehold REIT	919.2	Industrial
4	IMPACT Growth REIT	865.1	Specialty
5	WHA Premium Growth Freehold and Leasehold REIT	773.4	Industrial
6	Samui Airport Property Fund Leasehold	671.1	Specialty
7	CP Tower Growth Leasehold Property Fund	377.2	Office
8	Future Park Leasehold Property Fund	367.6	Retail
9	Golden Ventures Leasehold REIT	357.9	Office
10	Quality Houses Leasehold Property Fund	320.7	Office
11	LH Hotel Leasehold REIT	267.6	Specialty
12	LH Shopping Centers Leasehold REIT	242.8	Retail
13	Thailand Prime Property Freehold and Leasehold REIT	211.9	Office
14	Bhiraj Office Leasehold REIT	199.4	Office
15	GLAND Office Leasehold REIT	181.1	Office
16	Hemaraj Leasehold REIT	144.6	Industrial
17	Millionaire Property Fund	128.4	Diversified
	Total	10,293.6	

Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

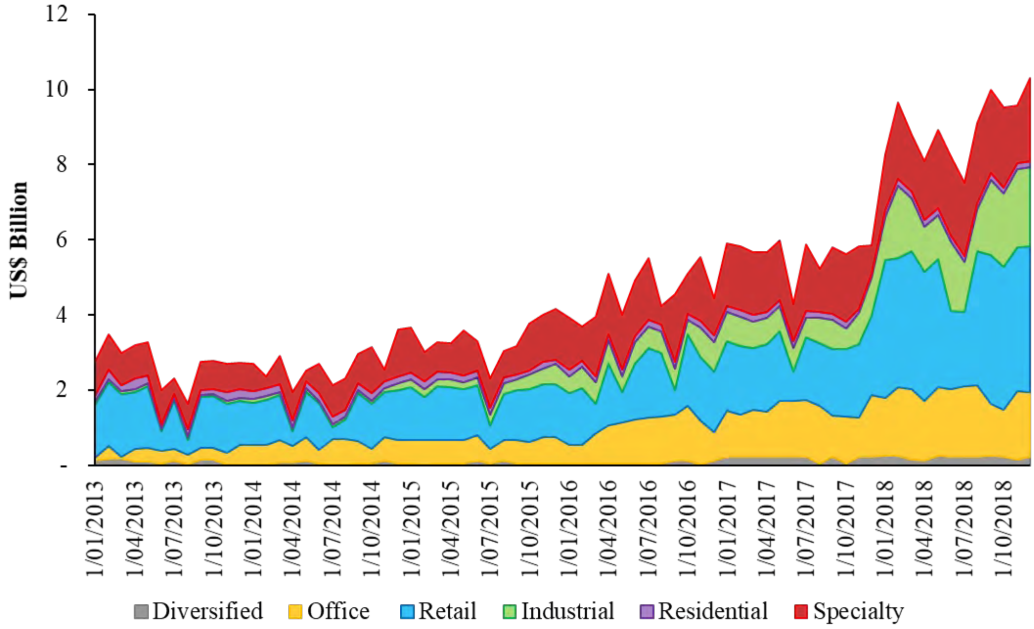
Table 2-24: Profiles of Thai-REITs: December 2018 (Cont1)

	REITs	Market cap (US$ M)	Property type*
18	Talaad Thai Leasehold Property Fund	122.2	Retail
19	Bualuang Office Leasehold REIT	121.2	Office
20	Amata Summit Growth Freehold and Leasehold REIT	118.7	Industrial
21	Strategic Hospitality Extendable Freehold and Leasehold REIT	98.1	Specialty
22	Sri Panwa Hospitality REIT	92.6	Diversified
23	Quality Houses Hotel and Residence Freehold and Leasehold Property Fund	86.2	Specialty
24	Land and Houses Freehold and Leasehold Property Fund	83.1	Residential
25	Dusit Thani Freehold and Leasehold REIT	62.9	Specialty
26	WHA Business Complex Freehold and Leasehold REIT	61.4	Office
27	Siri Prime Office Property Fund	59.5	Office
28	Grande Hospitality REIT	50.9	Specialty
29	KPN Property Fund	49.8	Office
30	AIM Industrial Growth Freehold and Leasehold REIT	48.6	Industrial
31	Sala @ Sathorn Property Fund	48.5	Office
32	Centara Hotels & Resorts Leasehold Property Fund	46.4	Specialty
33	Gold Property Fund Lease Hold	45.6	Residential
34	MFC Industrial Investment Property and Leasehold Fund	45.4	Industrial
35	MFC Patong Heritage Property Fund	31.6	Specialty
36	Erawan Hotel Growth Property Fund	28.7	Specialty
37	Thai Industrial Fund 1	24.1	Industrial
38	Quality Hospitality Leasehold Property Fund	18.9	Specialty
39	MFC-Nichada Thani Property Fund 2	15.4	Residential
40	Sub Sri Thai REIT	15.4	Office
41	MFC Strategic Storage Fund	14.5	Specialty
42	MFC Industrial REIT	13.1	Industrial
43	Sub Sri Thai Property Fund	13.1	Diversified
44	101 Montri Storage Property Fund	11.1	Industrial
45	Multi-National Residence Fund	10.6	Residential
46	Samui Buri Property Fund	7.1	Specialty
47	MFC-Nichada Thani Property Fund	6.3	Residential
48	TU Dome Residential Complex Leasehold Property Fund	5.4	Residential
49	Luxury Real Estate Investment Fund	-	Specialty
50	Urbana Property Fund Lease hold	-	Specialty
	Total	10,293.6	

Notice: *Categorised by the GICS

Source: Author’s compilation from Thomson Reuters Datastream

Figure 2-30: Growth in market capitalisation for Thai-REIT sub-sectors: July 2006–December 2018



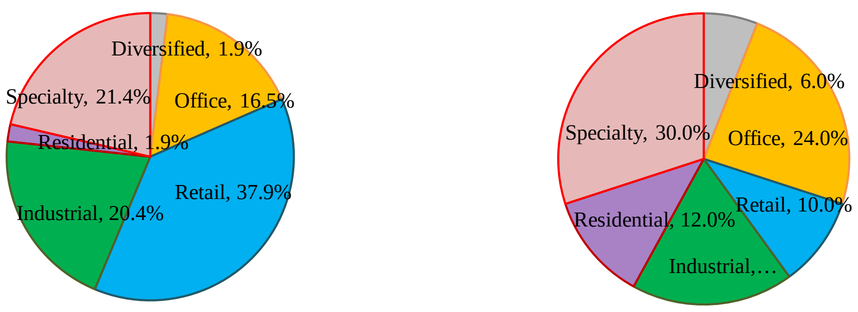
Source: Author's compilation/analysis from the constructed database

Table 2-25: Thai-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	1.7	12
Retail	3.9	5
Industrial	2.1	9
Residential	0.2	6
Specialty	2.2	15
Diversified	0.2	3
Total	10.3	50

Source: Author's compilation/analysis from the constructed database

Figure 2-31: Breakdown of Thai-REITs: December 2018

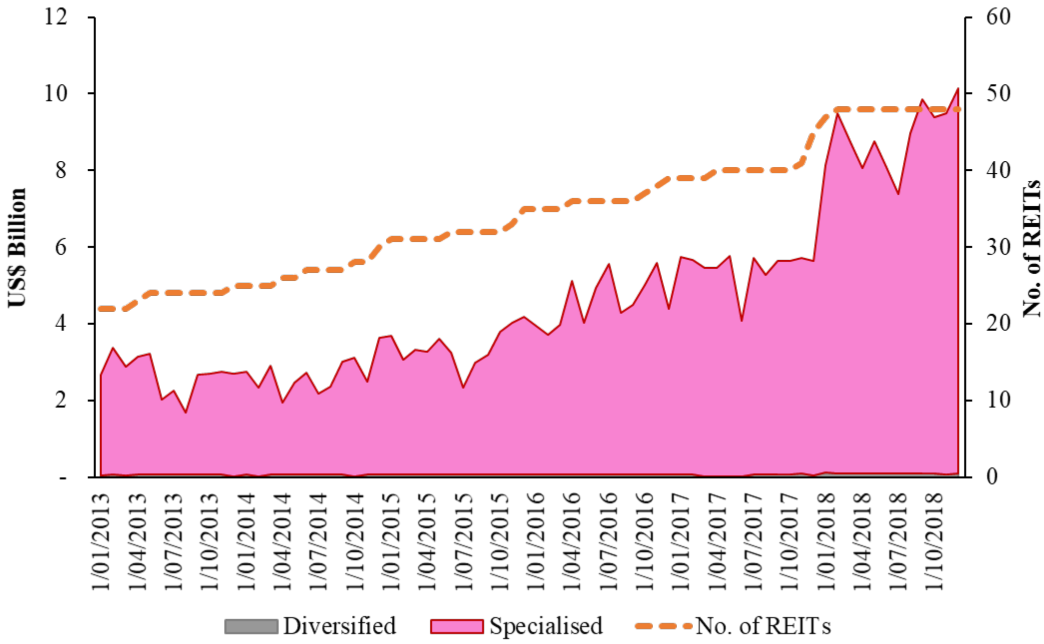


By Market Cap **By No. REITs**

Source: Author's compilation/analysis from the constructed database

Table 2-25 and **Figure 2-31** show the REIT sub-sectors of Thai-REITs as of December 2018. Retail REITs was the largest REIT sub-sector in Thai-REITs, accounting for US$3.9 billion and contributing 37.9% of Thai-REITs, with nine REIT equities. It was followed by specialty (No. 2 in Thai-REITs; 21.4% of Thai-REITs; US$2.2B; 15), industrial (No. 3; 20.4%; US$2.1B; 9); office (No. 4; 16.5%; US$1.7B; 12), diversified (No. 5; 1.9%; US$0.2B; 3) and residential REITs (No. 6; 1.9%; US$0.2B; 6). The prominent role of sector-specific REITs is observed in Thai-REIT sub-sectors. In particular, of 50 Thai-REITs, 47 are sector-specific REITs, while three are diversified REITs. **Figure 2-32** illustrates that sector-specific REITs have averagely represented approximately 93.6% of the total assets of Thai-REITs over the past 12 years. The primary role of sector-specific REITs has been evident in the Thai-REIT market from January 2013 to December 2018.

Figure 2-32: Growth in market capitalisation for sector-specific REITs in Thailand: specialised versus diversified: July 2006–December 2018



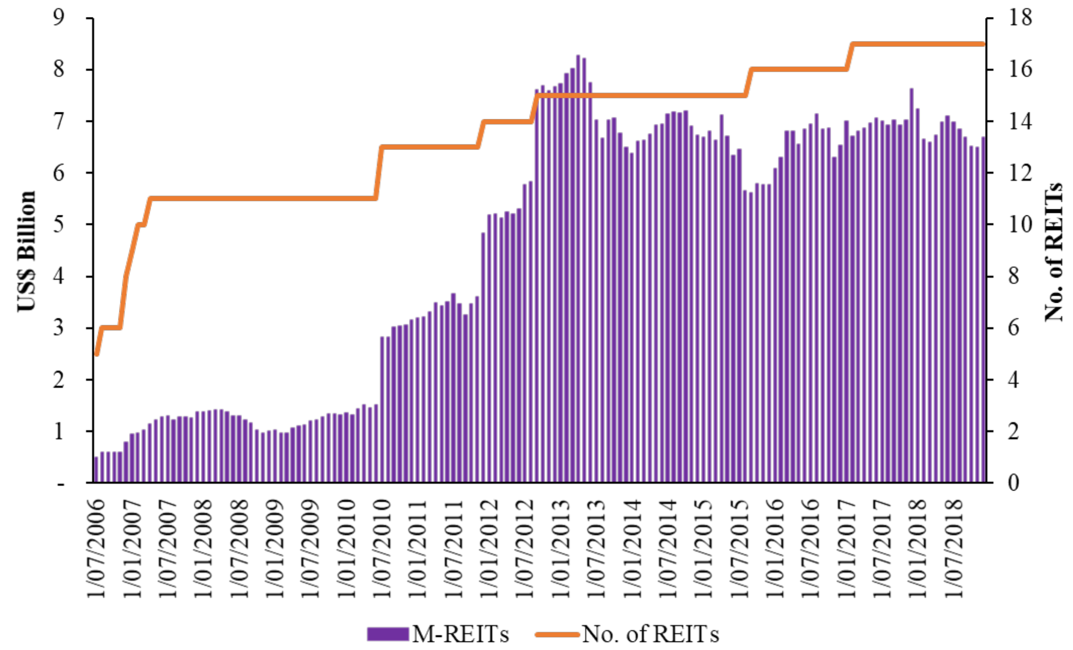
Source: Author's compilation/analysis from the constructed database

2.4.7 Malaysia

As the sixth largest REIT market in the Asia-Pacific, Malaysian REITs (M-REITs) increased market capitalisation from US$0.5 billion in July 2006 to US$6.7 billion in December 2018, a 13.2-fold increase, as illustrated in **Figure 2-33**. **Table 2-26** details that there were 17 REITs in the M-REIT market as of December 2018, including office, retail, industrial, specialty and diversified REITs. Pure residential REITs do not yet exist in M-REITs. **Figure 2-34** depicts the dynamic growth in market capitalisation of REIT sub-sectors in M-REITs from July 2006 to December 2018. With the fastest growth (49.6 times) by market capitalisation, retail REITs increased from US$90 million in December 2006 to US$4.6 billion at the end of 2018. Over the same period, the other REIT sub-sectors grew less rapidly: diversified (6.2 times), office (4.5), specialty (1.9) and industrial REITs (1.0). **Table 2-26** and **Figure 2-35** articulate the REIT sub-sectors in M-REITs as of December 2018. Retail REITs accounted for US$4.6 billion and formed 68.7% of M-REITs, as the largest REIT sub-sector in M-REITs with six REIT equities. It was followed by diversified (No. 2 in M-REITs; 10.4% of M-REITs; US$0.7B; 4 REITs), specialty (No.3; 10.4%; US$0.7B; 2), office (No. 4; 9.0%; US$0.6B; 4) and industrial REITs (No. 5; 1.5%; US$0.1B; 1). In addition to the property sector segment, the M-REIT market also includes Islamic REITs, namely Axis REIT (US$0.5B), Al-Aqar Healthcare REIT (US$0.2B) and Al-Salam REIT (US$0.1B).

The more substantial role of sector-specific REITs is seen in the REIT sub-sector segment in the M-REIT market. Of 17 M-REITs, 13 are sector-specific REITs, including IGB REIT (No. 1 in M-REITs; US$1.5B; retail), CapitaLand Malaysia Mall Trust (No. 4; US$0.5B; retail), Al-Aqar Healthcare REIT (No. 8; US$0.2B; specialty), UOA REIT (No. 9; US$0.1B; office) and Atrium REIT (No. 17; US$32.7M; industrial). On the other hand, four are diversified REITs, such as Axis REIT (No. 6; US$0.5B), AmanahRaya REIT (No. 11; US$0.1B), Al-Salam REIT (No. 12; US$0.1B) and Amanah Harta Tanah PNB (No. 16; US$41.5M) (**Table 2-26**). In particular, over 85.6% of a market capitalisation of M-REITs has been occupied by sector-specific REITs over the last 12 years, as illustrated in **Figure 2-36**. Sector-specific REITS increased total assets from US$0.4 billion in July 2006 to US$5.9 billion in December 2018, a 15.4-fold increase. There is substantial evidence of the influential role of sector-specific REITs in the M-REIT market over the last 12 years.

Figure 2-33: Growth in market capitalisation for M-REITs: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

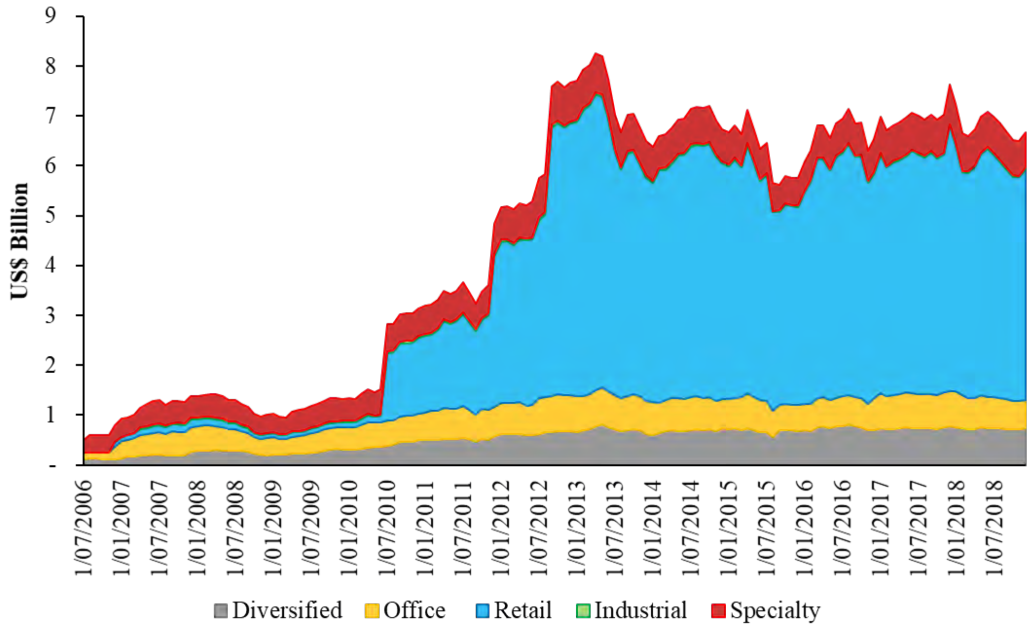
Table 2-26: Profile of M-REITs: December 2018

Rank	REITs	Market cap (US$ M)	Property types*
1	IGB REIT	1,479.8	Retail
2	Sunway REIT	1,232.9	Retail
3	Pavilion REIT	1,205.1	Retail
4	CapitaLand Malaysia Mall Trust	499.6	Retail
5	YTL Hospitality REIT	486.7	Specialty
6	Axis REIT	467.1	Diversified
7	MRCB-Quill REIT	274.9	Office
8	Al-Aqar Healthcare REIT	233.3	Specialty
9	UOA REIT	134.1	Office
10	Hektar REIT	124.1	Retail
11	AmanahRaya REIT	113.7	Diversified
12	Al-Salam REIT	113.0	Diversified
13	KIP REIT	91.7	Retail
14	AmFIRST REIT	87.2	Office
15	Tower REIT	62.5	Office
16	Amanah Harta Tanah PNB	41.5	Diversified
17	Atrium REIT	32.7	Industrial
	Total	6,679.9	

Notice: *Categorised by the GICS

Source: Author's compilation from Thomson Reuters Datastream

Figure 2-34: Growth in market capitalisation for M-REIT sub-sectors: July 2006–December 2018



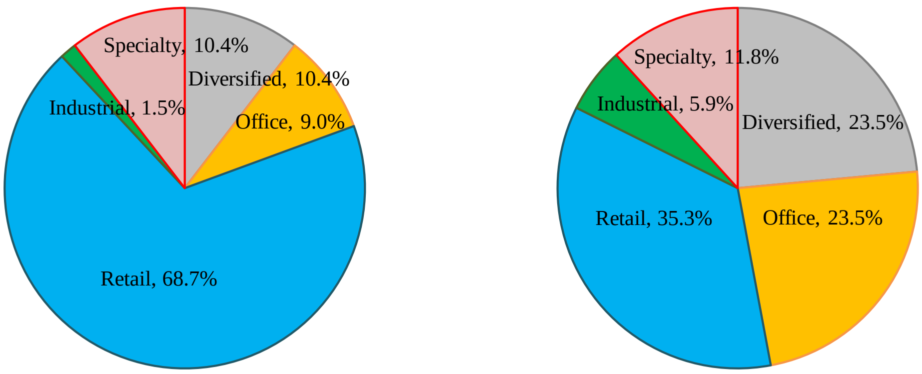
Source: Author's compilation/analysis from the constructed database

Table 2-26: M-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	0.6	4
Retail	4.6	6
Industrial	0.1	1
Specialty	0.7	2
Diversified	0.7	4
Total	6.7	17

Source: Author's compilation/analysis from the constructed database

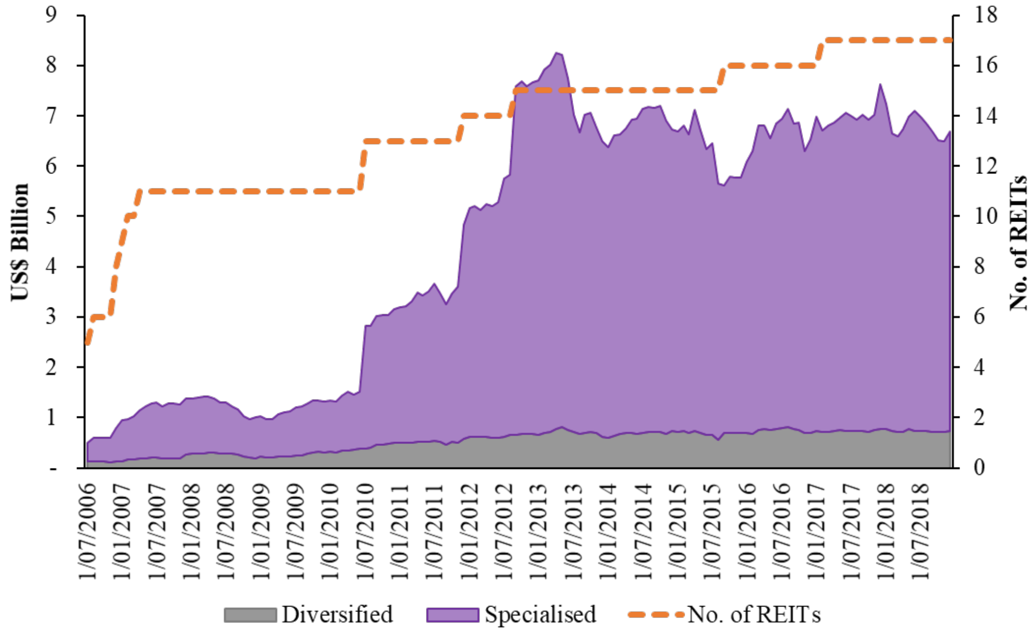
Figure 2-35: Breakdown of M-REITs: December 2018



By Market Cap **By No. REITs**

Source: Author's compilation/analysis from the constructed database

Figure 2-36: Growth in market capitalisation for sector-specific REITs in Malaysia: specialised versus diversified: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

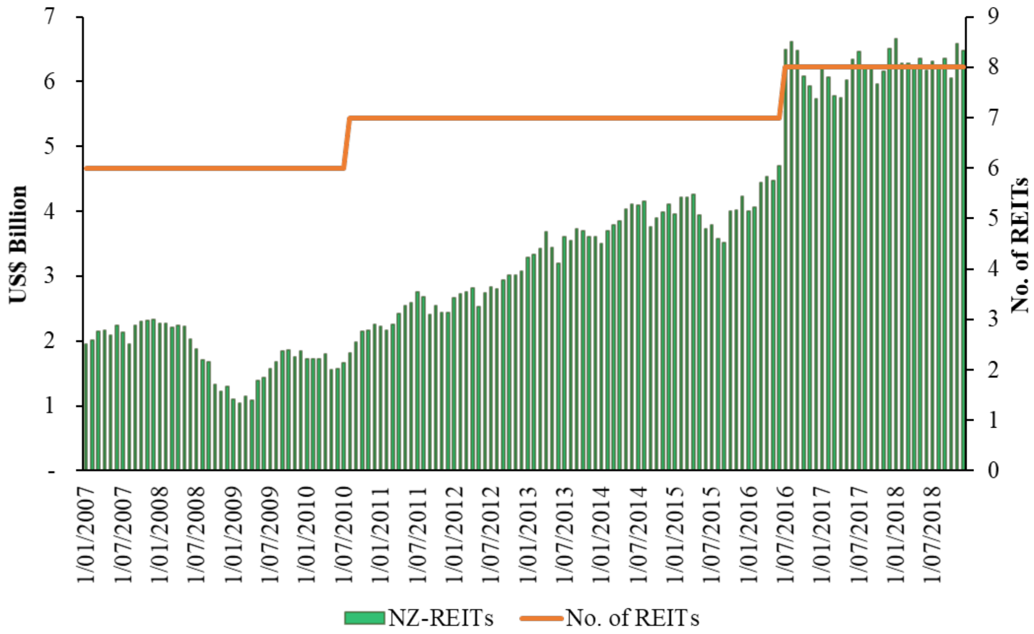
2.4.8 New Zealand

Introduced in 2007, New Zealand REITs (NZ-REITs) was the seventh largest REIT market in the Asia-Pacific region. NZ-REITs increased total assets from US$2.0 billion in 2007 to US$6.5 billion in 2018, a 4.5-fold increase since the launch date, as displayed in **Figure 2-37**. As of December 2018, NZ-REITs had 8 REIT equities, comprising office, retail, industrial, specialty and diversified REITs but lacking the pure residential REIT sub-sector, as shown in **Table 2-28**. **Figure 2-38** shows the REIT sub-sector dynamic segment of NZ-REITs from 2013 to 2018. The growth of specialty REITs (4.3 times) was greater than that of other REIT sub-sectors since 2013, including office (3.5), diversified (3.0), industrial (2.7) and retail REITs (1.0).

Unlike the other REIT markets in the Asia-Pacific, diversified REITs was the largest REIT sub-sector in the NZ-REIT market, accounting for US$2.5 billion and representing 38.5% of the size of NZ-REITs, with 3 REITs. It was followed by retail (No. 2 in NZ-REITs; 24.6%of NZ-REITs; US$1.6B; 2), office (No. 3; 18.5%; US$1.2B; 1), specialty (No. 4; 9.2%; US$0.6B; 1) and industrial REITs (No. 5; 9.2%; US$0.6B; 1), as documented in **Table 2-28** and **Figure 2-39**. Of eight NZ-REITs, three are diversified REITs, such as Goodman Property Trust Units (No. 1 in NZ-REITs; US$1.3B), Argosy Property (No. 4;

US$0.7B) and Stride Stapled Group (No. 7; US$0.5B). Despite diversified REITs being the most substantial REIT sub-sector in NZ-REITs, sector-specific REITs occupied most of the total assets of NZ-REITs as of December 2018, including Kiwi Property Group (No. 2; US$1.3B; retail), Precinct Properties New Zealand (No. 3; US$1.2B; office), Vital Healthcare Property Trust (No. 5; US$0.6B; specialty) and Property for Industry (No. 6; US$0.6B; industrial). **Figure 2-40** illustrates that sector-specific REITs represented, on average, 49.2% of NZ-REITs. In general, sector-specific REITs have not played a primary role among NZ-REITs over the last 12 years.

Figure 2-37: Growth in market capitalisation for NZ-REITs: July 2006–December 2018



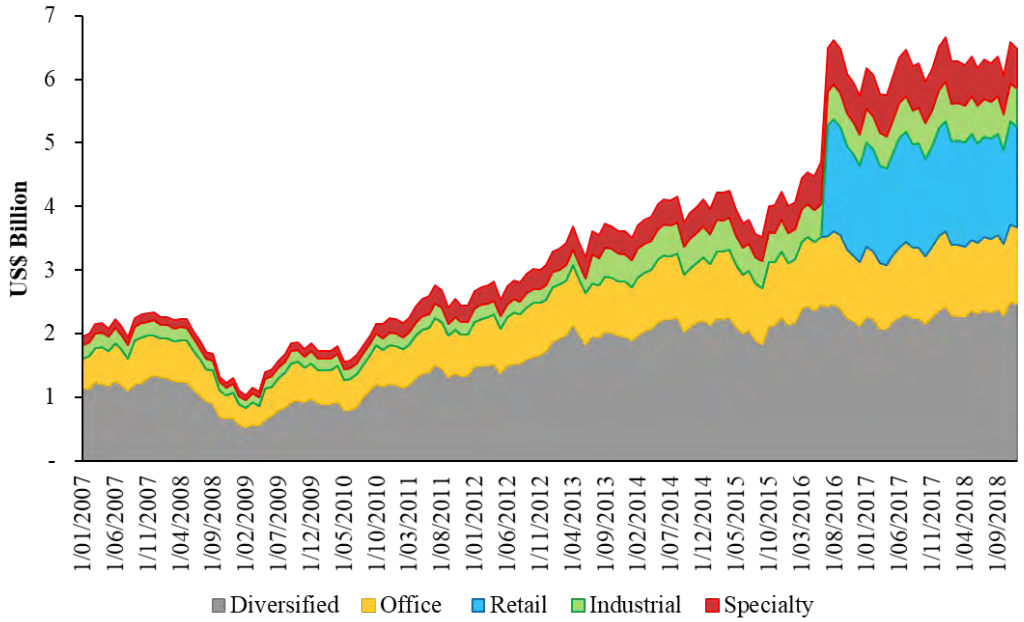
Source: Author's compilation/analysis from the constructed database

Table 2-27: Profile of NZ-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	Goodman Property Trust Units	1,328.5	Diversified
2	Kiwi Property Group	1,311.5	Retail
3	Precinct Properties New Zealand	1,202.0	Office
4	Argosy Property	665.5	Diversified
5	Vital Healthcare Property Trust	623.4	Specialty
6	Property for Industry	605.3	Industrial
7	Stride Stapled Group	472.7	Diversified
8	Investore Property	267.1	Retail
	Total	6,476.0	

Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-38: Growth in market capitalisation for NZ-REIT sub-sectors: July 2006–December 2018



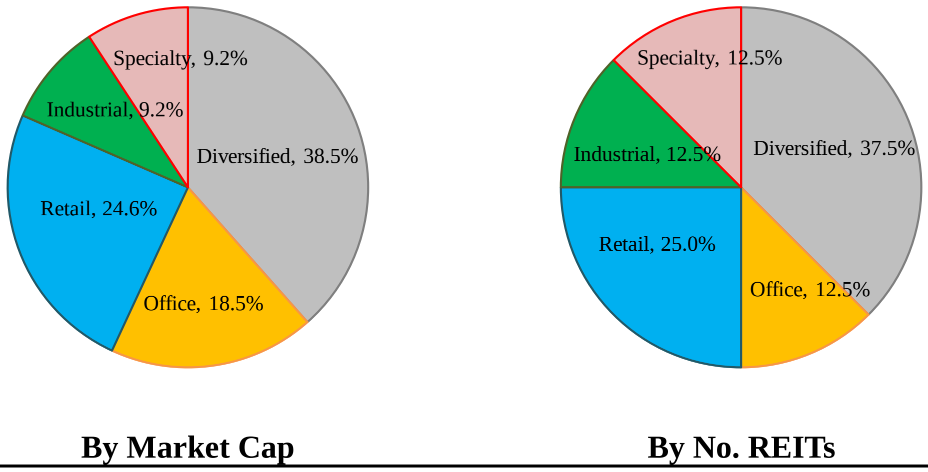
Source: Author's compilation/analysis from the constructed database

Table 2-28: NZ-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$ B)	No. of REITs
Office	1.2	1
Retail	1.6	2
Industrial	0.6	1
Specialty	0.6	1
Diversified	2.5	3
Total	6.5	8

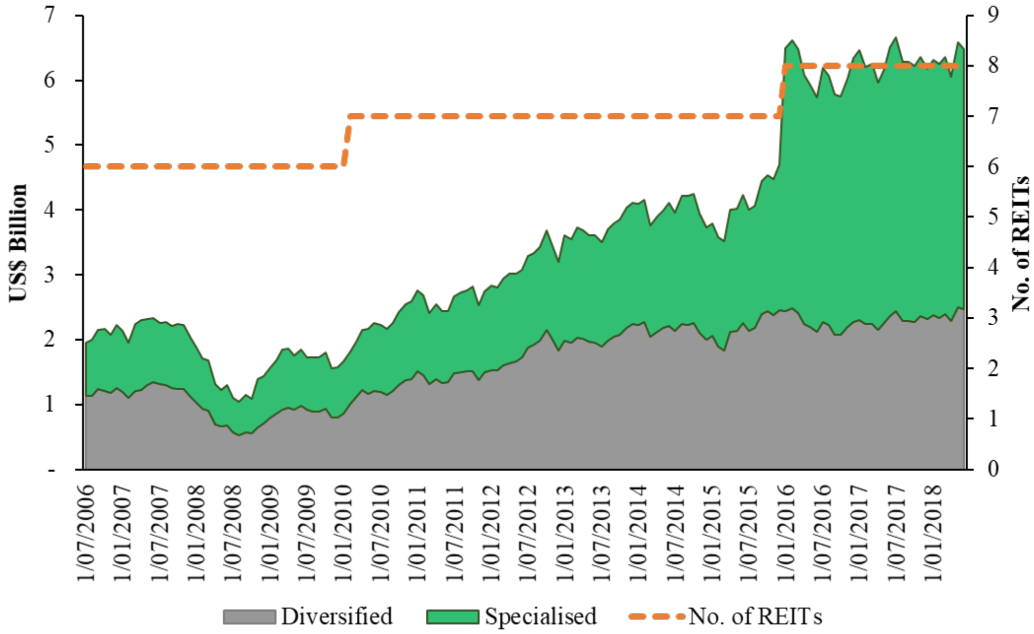
Source: Author's compilation/analysis from the constructed database

Figure 2-39: Breakdown of NZ-REITs: December 2018



Source: Author's compilation/analysis from the constructed database

Figure 2-40: Growth in market capitalisation for sector-specific REITs in New Zealand: specialised versus diversified: July 2006–December 2018



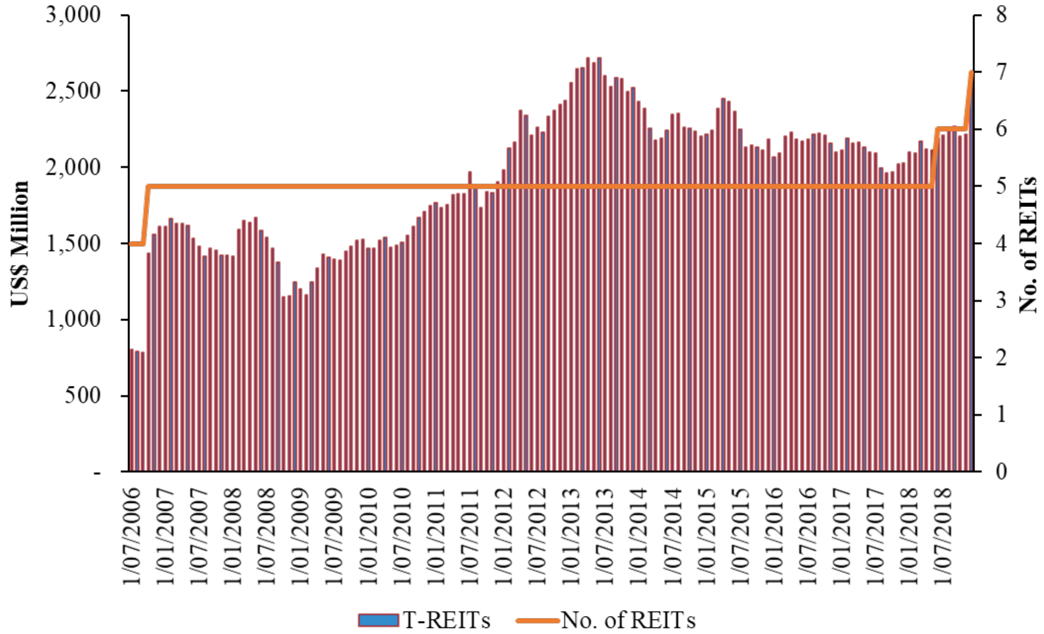
Source: Author's compilation/analysis from the constructed database

2.4.9 Taiwan

Introduced in 2004, Taiwan REITs (T-REITs) increased market capitalisation from US$0.8 billion in July 2006 to US$2.6 billion in December 2018, a 3.2-fold increase, as presented in **Figure 2-41**. As of December 2018, T-REITs comprised seven REIT equities, consisting only of office and diversified REITs and lacking the pure retail, industrial, residential and specialty REITs, as reported in **Table 2-29**. Unlike the other REIT markets in the Asia-Pacific, diversified REITs was the largest sector in the T-REIT market, accounting for US$1.7 billion and representing 64.0% of T-REITs, with four REIT equities, as documented in **Figure 2-42**, **Table 2-30** and **Figure 2-43**.

The more substantial role of diversified REITs was also evident from the fact that four out of seven T-REITs are diversified REITs (**Table 2-29**). These are O-Bank No.1 REIT (No. 1 in T-REITs; US$835.5M), Cathay No.1 REIT (No. 2; US$673.5M), Shin Kong No.1 REIT (No. 3; US$554.0M) and Fubon No.1 REIT Fund (No. 7; US$278.8M). On the other side, sector-specific REITs contributed only 36.0% of the total assets of T-REITs. These sector-specific REITs are all office sector REITs, such as Cathay No.2 REIT (No. 4; US$352.1M), Millerful No.1 REIT (No. 5; US$346.0M) and Fubon No.2 REIT (No. 6; US$299.3M). Diversified REITs have averagely represented over 56.8% of T-REITs over the last 12 years. The more substantial role of diversified REITs can be observed in T-REITs from July 2006 to December 2018, as displayed in **Figure 2-44**. Similar evidence was seen in the NZ-REIT market. Despite T-REITs being one of the earlier REIT markets in the Asia-Pacific, the size of T-REITs by market capitalisation is not comparable to that the other Asia-Pacific REIT markets, which have specialised in sector-specific REITs. The smaller size of T-REITs may be attributed to the lack of sector-specific REITs in the T-REIT market over the last ten years.

Figure 2-41: Growth in market capitalisation for T-REITs: July 2006–December 2018



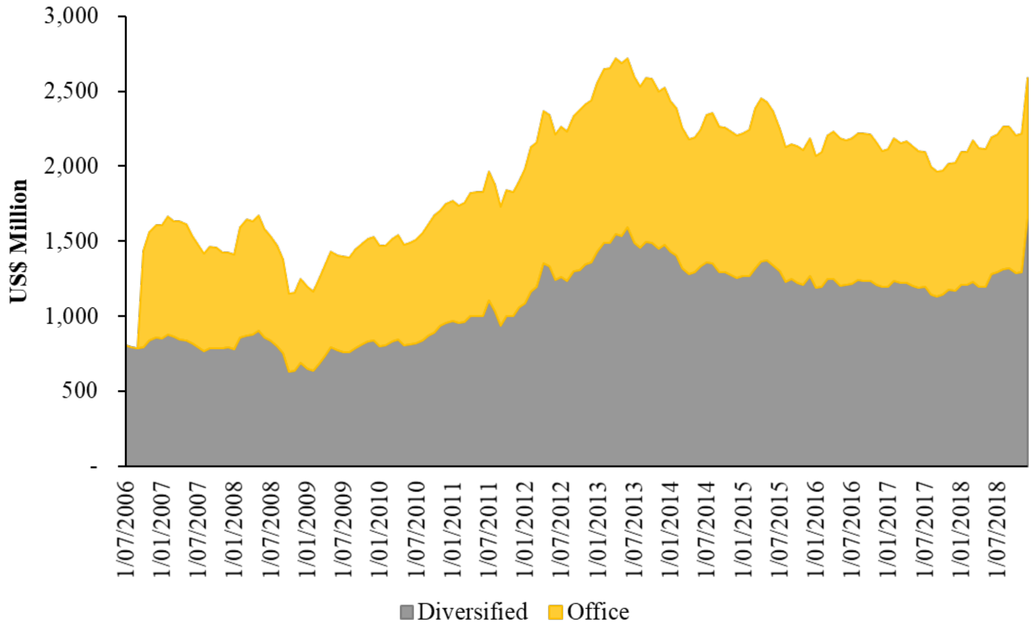
Source: Author's compilation/analysis from the constructed database

Table 2-29: Profile of T-REITs: December 2018

Rank	REITs	Market cap (US$ M)	Property type*
1	O-Bank No.1 REIT	835.5	Diversified
2	Cathay No.1 REIT	673.5	Diversified
3	Shin Kong No.1 REIT	554.0	Diversified
4	Cathay No.2 REIT	352.1	Office
5	Millerful No.1 REIT	346.0	Office
6	Fubon No.2 REIT	299.3	Office
7	Fubon No.1 REIT Fund	278.8	Diversified
	Total	2,587.3	

Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-42: Growth in market capitalisation for T-REIT sub-sectors: July 2006–December 2018



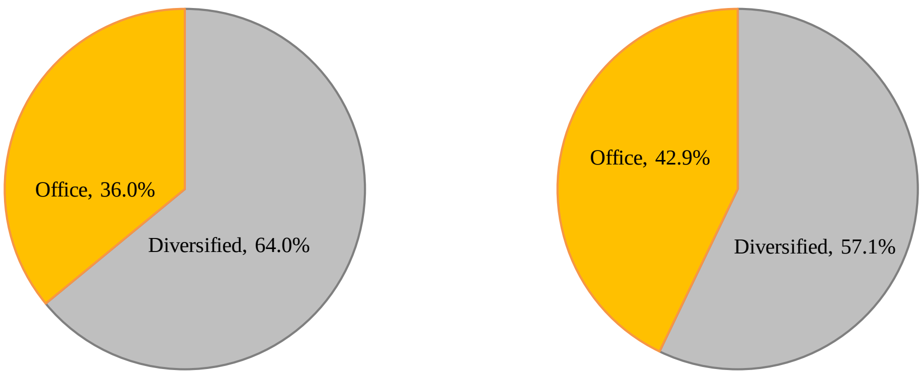
Source: Author's compilation/analysis from the constructed database

Table 2-30: T-REITs by property types: December 2018

REIT sub-sectors	Market cap (US$ M)	No. of REITs
Office	930.2	3
Diversified	1,657.0	4
Total	2,587.3	7

Source: Author's compilation/analysis from the constructed database

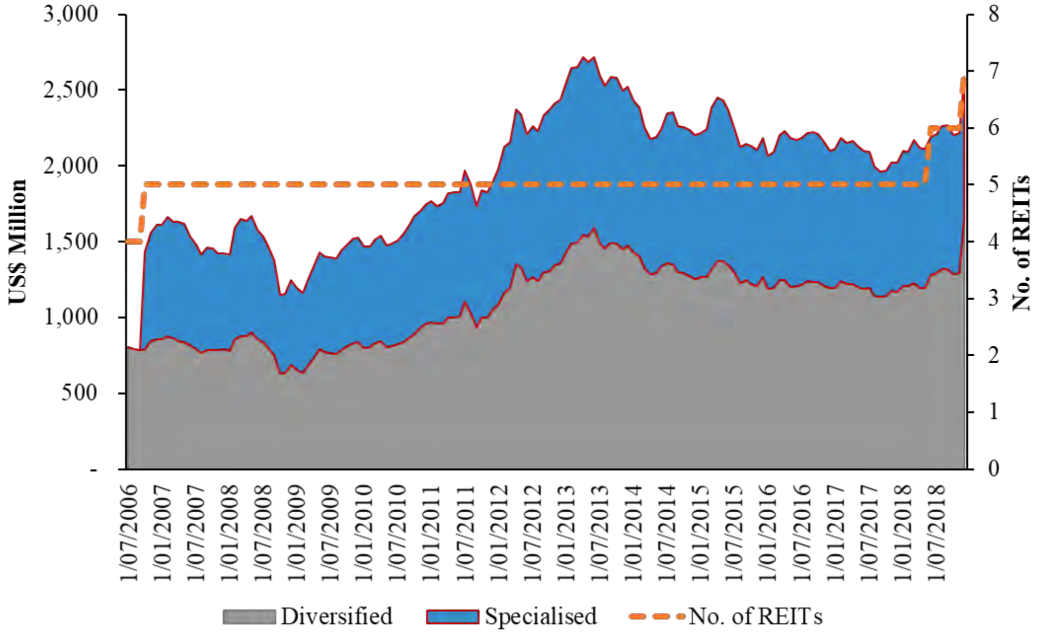
Figure 2-43: Breakdown of T-REITs: December 2018



By Market Cap **By No. REITs**

Source: Author's compilation/analysis from the constructed database

Figure 2-44: Growth in market capitalisation for sector-specific REITs in Taiwan: specialised versus diversified: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

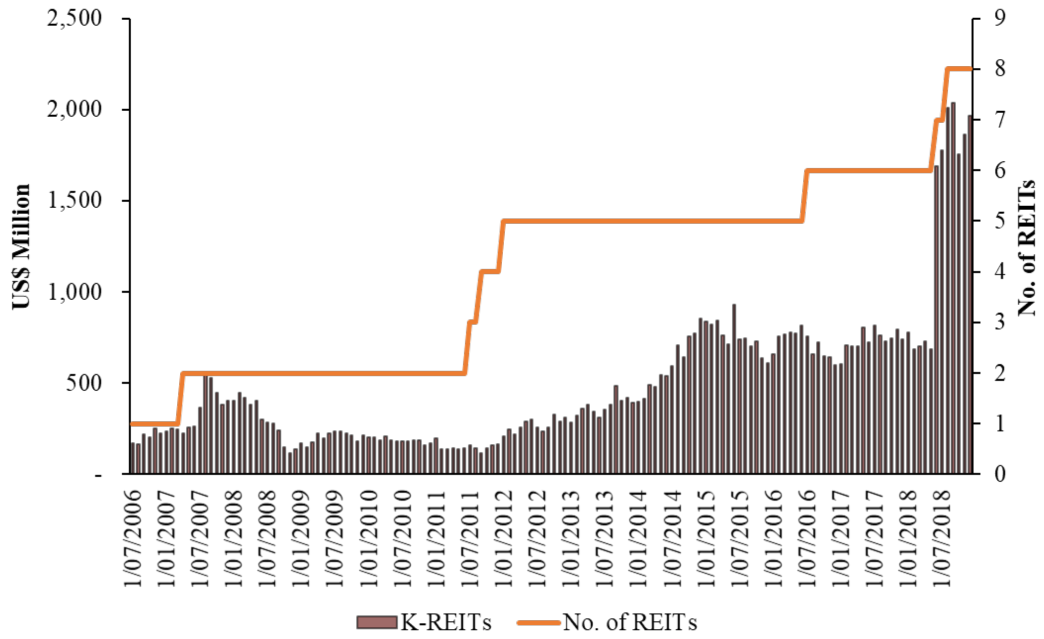
2.4.10 South Korea

South Korea REITs (K-REITs) increased market capitalisation from US$0.2 billion in July 2006 to US$2.0 billion in December 2018, an 11.5-fold increase, as presented in **Figure 2-45**. As of December 2018, K-REITs comprised eight REIT equities, across three REIT sub-sectors: office, residential and diversified REITs. The pure retail, industrial and specialty REITs do not exist in the K-REIT market, as documented in **Table 2-27**.

By REIT sub-sector, residential REITs have a long history in the K-REIT market, while office and diversified REITs have emerged in recent years, as seen in **Figure 2-46**. As of December 2018, diversified REITs was the largest REIT sub-sector in K-REITs, with the total assets of US$1.086.9 billion and five REIT equities. It contributed more than half of K-REITs, followed by residential (31.1%; US$611.0M; 1 REITs) and office REITs (13.6%; US$267.4M; 2), as seen in **Table 2-28** and **Figure 2-47**. Diversified REITs was seen as the prominent sector in K-REITs, despite having a comparatively short history in the K-REIT market. As displayed in **Table 2-27**, five of eight K-REITs are diversified REITs, while three are sector-specific REITs, including two office REITs and one residential REIT.

This confirms the substantial role of diversified REITs in the K-REIT market. However, since diversified REITs have had one a one-year history in K-REITs, sector-specific REITs have, on average, contributed over 97.3% of K-REITs over the last 12 years, as displayed in **Figure 2-48**. Before the introduction of diversified REITs a year ago, the more influential role of sector-specific REITs in the K-REIT market since July 2006 (unlike the REIT markets in New Zealand and Taiwan was apparent).

Figure 2-45: Growth in market capitalisation for K-REITs: July 2006–December 2018



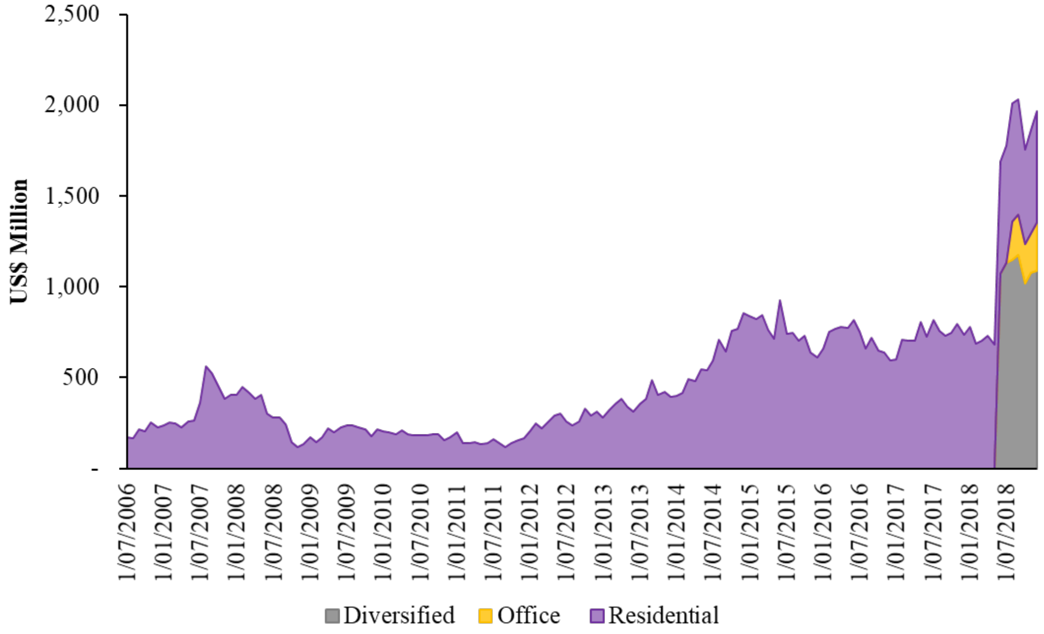
Source: Author's compilation/analysis from the constructed database

Table 2-27: Profile of K-REITs: December 2018

	REITs	Market cap (US$ M)	Property type*
1	Korea REIT	611.0	Residential
2	Korea Asset in Trust	445.0	Diversified
3	MiraeAsset Maps Asia-Pacific Real Estate 1 Investment	303.7	Diversified
4	E Kocref CR-REIT	275.3	Diversified
5	Shinhan Alpha REIT	240.0	Office
6	K Top REITS	46.5	Diversified
7	Trus Y 7 REIT	27.5	Office
8	A Self-Administered REIT	16.4	Diversified
	Total	1,965.4	

Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-46: Growth in market capitalisation for K-REIT sub-sectors: July 2006–December 2018



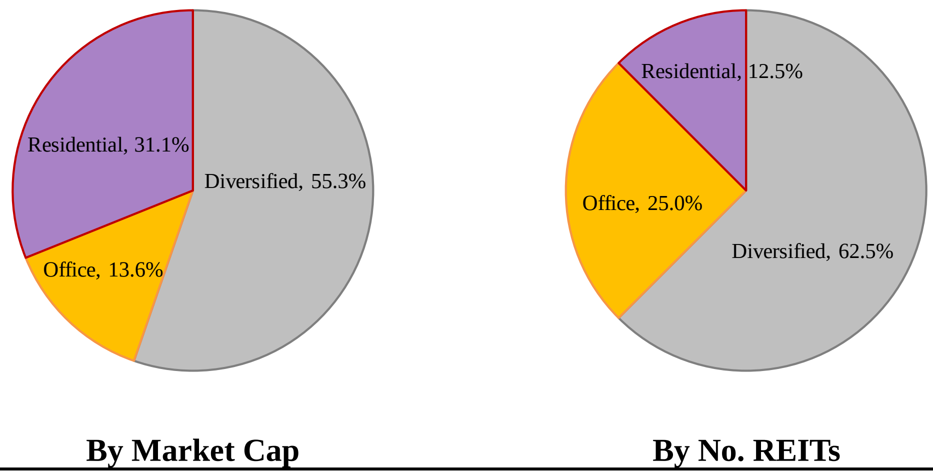
Source: Author's compilation/analysis from the constructed database

Table 2-28: K-REITs by property types: December 2018

Property Sector	Market cap (US$ M)	No. of REITs
Office	267.4	2
Residential	611.0	1
Diversified	1,086.9	5
Total	1,965.2	8

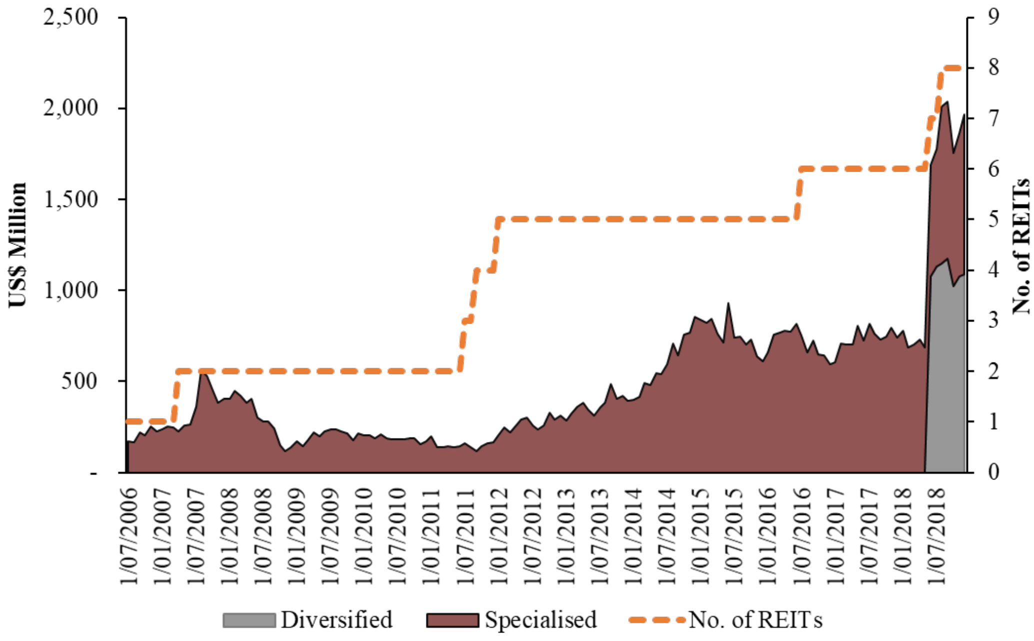
Source: Author's compilation/analysis from the constructed database

Figure 2-47: Breakdown of K-REITs: December 2018



Source: Author's compilation/analysis from Thomson Reuters Eikon

Figure 2-48: Growth in market capitalisation for sector-specific REITs in South Korea: specialised versus diversified: July 2006–December 2018



Source: Author's compilation/analysis from the constructed database

2.4.11 Pakistan and Indonesia

Table 2-29 and **Figure 2-49** profile REITs in Pakistan and Indonesia. Pakistan launched its first REITs in 2015, accounting for US$192.1 million, with one REIT equity, namely Dolmen City REIT. It is categorised as diversified REITs, owning and managing one mixed-used property in Pakistan, with a mix of retail and office space. As of December 2018, Indonesian REITs had one REIT, Dana Investasi Real Estat Ciptadana Properti Ritel Indonesia. It is classified as a retail REIT, with a market capitalisation of US$27.8 million.

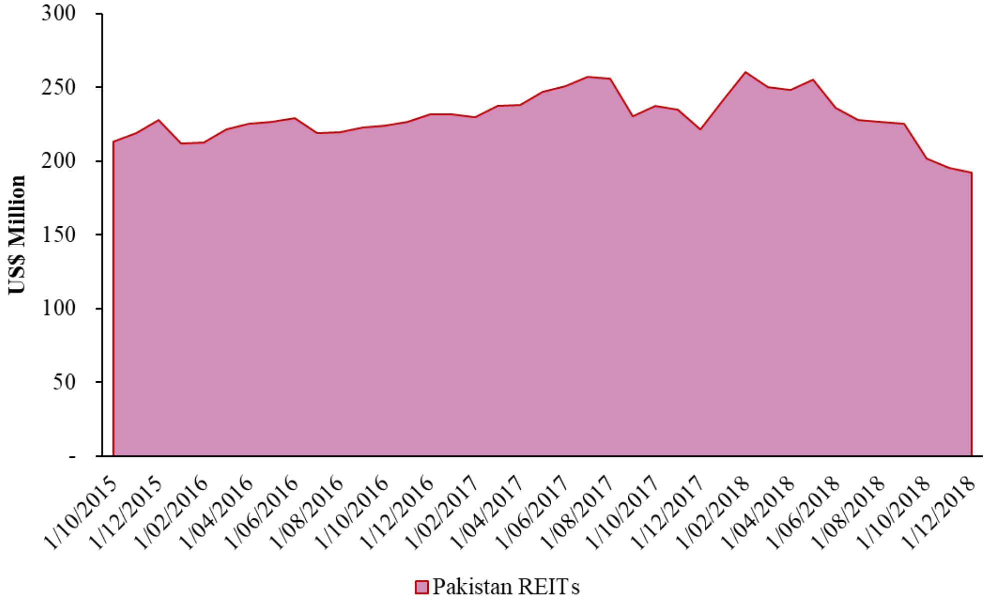
Table 2-29: Profile of REITs in Pakistan and Indonesia: December 2018

Panel A Pakistan	REITs	Market cap (US$ M)	Property type*
	Dolmen City REIT	192.1	Diversified
Panel B Indonesia	REITs	Market cap (US$ M)	Property type*
	Dana Investasi Real Estat Ciptadana Properti Ritel Indonesia	27.8	Retail

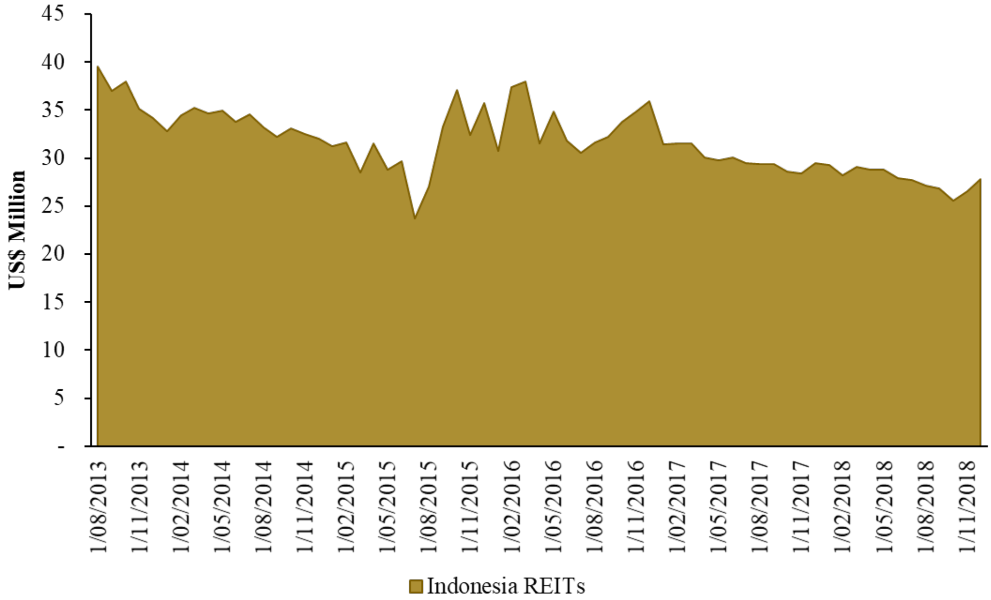
Notice: *Categorised by the GICS
Source: Author's compilation from Thomson Reuters Datastream

Figure 2-49: Growth in market capitalisation for REITs in Indonesia and Pakistan: July 2006–December 2018

Panel A: Pakistan



Panel B: Indonesia



Source: Author's compilation/analysis from the constructed database

2.5 SUMMARY OF CHAPTER

The principal aim of this chapter was to highlight the significant status of Asia-Pacific REITs in the international property investment space, with a primary focus on the sector-specific REITs in the Asia-Pacific region. Since 1971, Asia-Pacific REITs have grown significantly, with a market capitalisation of US$327.8 billion and 247 REIT equities across 11 markets in 2018. These markets include Japan, Australia, Singapore, Hong Kong, Thailand, Malaysia, New Zealand, Taiwan, South Korea, Pakistan and Indonesia. India and the Philippines introduced REITs in 2019 and 2020 respectively. As of December 2018, Asia-Pacific REITs contributed 21.4% of the total assets of international REITs and represented 10.5% of the market capitalisation of the global listed property investment space (EPRA, 2018c). The fast growth of Asia-Pacific REITs can be attributed to the solid commercial property market fundamentals in the Asia-Pacific region, underpinned by the strong population and healthy GDP outputs in the region (JLL, 2016a, CBRE, 2018a, b; PREI, 2017b).

In the Asia-Pacific REIT context, one of the prevailing attributes of REITs is that sector-specific REITs (e.g. Link REIT (retail), Goodman (industrial), Nippon Building Fund (office), Advance Residence (residential), Keppel DC REIT (specialty)) play a leading role in the markets compared to diversified REITs (e.g. Stockland). Sector-specific REITs have averagely contributed 78.2% of the size of Asia-Pacific REITs over the past 12 years, with a 2.7-fold increase since July 2006. This phenomenon was also observed in the Americans (93% of the size of REIT markets) and European REIT markets (72%) in 2018. These have seen sector-specific REITs play a primary role in the international REIT investment space compared to their diversified counterparts.

At a country level, the prevailing role of sector-specific REITs has been mostly witnessed across Japan (No. 1 in the Asia-Pacific), Australia (No. 2), Singapore (No. 3), Hong Kong (No. 4), Thailand (No. 5) and Malaysia (No. 6) over the last 12 years, but not in New Zealand (No. 7) or Taiwan (No. 8), which were comparatively small markets in the Asia-Pacific REIT universe in 2018. At a single REIT sub-sector level, retail REITs was the most significant contributor to the REIT markets across Australia, Singapore, Hong Kong, Thailand and Malaysia, while office REITs was the largest REIT sub-sector in Japan. As of December 2018, there were 192 REIT equities for sector-specific REITs, outnumbering diversified REITs (55 REITs). This manifests sector-specific REITs as the favoured structure to meet REIT investor appetite. The prosperity of sector-specific REITs in the Asia-Pacific offers institutional investors effective listed property investment exposure to tap into the potential of commercial properties professionally managed by a high-level property-specific fund managers in the region, with the added benefits of liquidity, transparency and fiscal efficiency.

The preferred REIT structure of sector-specific REITs is consistent with the sophisticated institutional investor appetite (Capozza and Seguin, 1999). The effect of specialisation value in the finance literature can explain this market phenomenon, positing that a single-business segment trades at a premium over their diversified counterparts (Hyland and Diltz, 2002; Villalonga, 2004). Given the increasing importance of sector-specific REITs in the Asia-Pacific REIT investment space, it is imperative to ascertain the existence of REIT specialisation value in the Asia-Pacific. In the Asia-Pacific REIT context, Japan, Australia and Singapore have averagely contributed 86.6% of the Asia-Pacific REIT markets from July 2006 to December 2018. The representative status of these three markets has been witnessed in the Asia-Pacific region. Data on REIT sub-sector equities in the other Asia-Pacific REIT markets are too thin to offer a comprehensive understanding of REIT specialisation value in the Asia-Pacific region.

Therefore, this thesis aims to remedy this critical issue by assessing aspects of the investment performance and role of sector-specific REITs in multi-asset portfolios in domestic, regional and global investment contexts across Japan, Australia and Singapore, compared with diversified REITs. Five different property types of regional REIT-based portfolios will be undertaken to reflect that international property investors have a mandate to invest the regional REIT-based portfolio from a practical point of view. Further, the interest rate sensitivity of sector-specific REITs will be analysed. These issues will be discussed in Chapter 3, and the analyses will be discussed in Chapter 5, 6, 7, 8 and 9. The rigorously empirical insights are expected to enable international property investors, particularly REMFs/PSFs and income-oriented investors, to make more informed and practical decisions regarding sector-specific REITs in the Asia-Pacific, with significant property investment implications.

CHAPTER 3
LITERATURE REVIEW

Chapter 3 reviews the scholarly literature on the risk-adjusted performance, portfolio diversification benefits, risk-adjusted performance comparisons, roles in mixed-asset portfolios and the interest rate sensitivity of sector-specific REITs in the Asia-Pacific context. The primary objective of this chapter is to offer a theoretical background of this research, and to identify the research gaps in the context of property investment space.

3.1 INTRODUCTION

This chapter will illustrate the theoretical and methodological background associated with the significance, investment performance, portfolio diversifications, roles in mixed-asset portfolios and interest rate sensitivity of REITs in general and REIT sub-sectors in particular. The review primarily focuses on the rationale for comparing the investment performance of different property types of REITs and diversified REITs. To shed light on the literature coverage of the REIT investment channels across the Asia-Pacific, the reviewed scholarly literature will be segregated into four geographical markets: Japan, Australia, Singapore and the USA.

3.2. OVERVIEW OF PROPERTY INVESTMENT

3.2.1 Role of Property in Mixed-asset Portfolios

Commercial property has been increasingly important in the international investment space in recent years. For retail and institutional investors, commercial property is characterised by distinct market cycles from the mainstream asset classes, such as stocks, bonds and cash. As it can provide attractive risk-return profiles, an increased level of institutional investor interest in mixed-asset portfolios has been witnessed in recent years (Burns and Epley, 1982; Webb and Rubens, 1986, 1987; Hartzell; 1986; Kuhle, 1987; Webb *et al*., 1988; Giliberto, 1992; Mueller *et al*., 1994; Bajtelsmit and Worzala, 1995; Kallberg *et al*., 1996; Mull and Soenen, 1997; Kallberg *et al*., 2000; Anderson and Springer, 2003; Feldman, 2003; Stephen and Simon, 2005; Cici *et al*., 2011; Pagliari, 2017). With unique investment features that are fundamentally distinct from stocks, bonds and cash, property has been seen as one of the four permanent mainstream investment asset classes by both institutional and retail investors in the international context (Geltner et al., 2014). These unique investment features result in property being an essential element of the multi-asset investment portfolios by potentially characterising distinct investment performance profiles, offering portfolio diversification benefits and decreasing portfolio risk, as well as enhancing portfolio returns for investors in the international context. Besides, income stability, capital growth, tax reduction and effective hedging against inflationary pressure are other critical investment benefits of the property markets (Hartzell, 1986; Baum and Hartzell 2012).

Numerous scholars have suggested institutional investors should consider including property in mixed-asset portfolio holdings, although consensus on the optimum weight of property in mixed-asset portfolios has yet to be reached. At the higher end, Webb *et al*. (1988) suggest that 66% of investment should be allocated to property and 34% to other financial assets. Feldman (2003) recommends the optimal allocation of property at more than 40%; likewise, Webb and Rubens (1986; 1987) claim that the optimal portfolio allocation to US residential property was 0–22%, with the optimal allocation to commercial property ranged from 49% to 83%.

At the lower end, a survey by Bajtelsmit and Worzala (1995) concludes that US pension funds allocated an average of 4.48% of portfolios to property. Similarly, Hartzell (1986) finds that the optimal allocation of property is 3–11%, while Giliberto (1992) suggests 5–15% as the optimal range. Kallberg *et al.* (1996) find that 9% should be allocated to property in a mixed-asset portfolio.

Falling between these extremes, the optimal composition of property has been assessed as 15–20% in multi-asset portfolios, primarily supported by Fogler (1984), Cooperman *et al*. (1984), Gold (1985), Brinson *et al*. (1986), Irwin and Landa (1987), Ennis and Burik (1991) MacGregor and Nanthakumaran (1992), Brown and Schuck (1996) and Lee *et al*. (1996) and Ziobrowski and Ziobrowski (1997).

The wide range of property investment channels for property investors can be categorised into two main property investment vehicles: direct property and indirect property (Baum and Hartzell 2012). Direct property investment refers to investors possessing and controlling the physical property. This form of investment is a capital-intensive activity and requires a wide range of active and specialist property management skills. This limits the threshold to investors with large amounts of capitals (institutional investors) in a private marketplace (Geltner et al., 2014). The roles of direct and indirect property in a single asset portfolio and mixed-asset portfolios are presented in **Table 3-1**.

Table 3-1: Roles of direct and indirect property in a single asset portfolio and mixed-asset portfolios

	Single asset portfolio	**Mixed-asset portfolio**
Direct property	1. Sector-specific property portfolio	1. Sector-specific property in mixed-asset portfolios
	2. Diversified property portfolio	2. Diversified property in mixed-asset portfolios
Indirect property	1. REIT portfolio	1. REITs in mixed-asset portfolios
	2. Property share portfolio	2. Property shares in mixed-asset portfolios

Source: Author's compilation

3.2.2 Linkage between REITs and Direct Property

Amongst various property investment conduits, property investment via a non-listed vehicle is the mainstream route for large-scale global institutional investors. This form of direct property investment allows investors to possess and control the management of the physical property (Newell, 2019). In other words, the format of direct property investment is a capital-intensive activity and requires a wide range of active and specialist property management skills, attracting several scholarly studies (Pagliari *et al*. 2005; Riddiough *et al*., 2005; Adair *et al*., 2006a, b; Eves, 2011; Ke and White, 2013, 2015; Ke and Sieracki, 2015; Marzuki and Newell, 2017), including residential property investment (Adair *et al*., 2000; Eves and Adair, 2005; Lee and Reed, 2014a, b; Lee *et al*., 2017; Newell and Lee, 2011). Specifically, these studies found that direct real estate is an effective investment vehicle in a mixed-asset portfolio (Ke and White, 2013; Lee, 2008, 2017). However, the above features also result in several weaknesses of direct property investment, such as the large size of investments, relatively low liquidity, the smaller number of market participants, high transaction costs, the need for local knowledge and management burdens (Seiler *et al*., 2001; Wilson and Zurbruegg, 2003b; Hoesli *et al*., 2015).

Compared with direct property, REITs have been seen as one of the most successful indirect property investment conduits, able to overcome these drawbacks, and have drawn more attention from practitioners and scholars in recent years (Hoesli *et al*., 2015; Lee and Lee, 2014). One question is whether, if both REITs and direct property are driven by the common property fundamentals, REITs should be expected to offer a similar level of portfolio diversification benefits to direct property does in a mixed-asset portfolio. On the other hand, if REITs are similar to stocks, REITs would not provide the beneficial portfolio diversifications characterised by direct property. Hence, the debate concerning whether REITs behave like direct property or common stocks has been heated in recent years.

Early 1990s literature argued that REITs had a weak statistical relationship with direct property, while REITs behaved more like stocks. Howe and Shilling (1988) observe that the stock price in the USA positively reacted to US debt REITs and negatively reacted to US equity REITs. The findings of Liu *et al*. (1990b) suggest that US equity REITs were empirically integrated with stocks in the USA, whereas US direct property was segmented from stocks. Liu and Mei (1992) aim to examine the predictability of US equity REIT returns and its co-movement with the other financial asset classes. Their results show that excess returns on US equity REITs were more predictable than bonds and small-cap stocks. In addition, US equity REITs were shown to move more closely with small-cap stocks than large-cap stocks in the USA.

Furthermore, Chan *et al*. (1990) find that US equity REIT returns were driven by unexpected inflation and changes in risk and the term structure of interest rates from 1973 to 1987. These variables were also found to explain approximately 60% of returns of stocks in the USA. Myer and Webb (1994) analyse the relationship between US equity REITs and stocks, as well as that of direct property and stocks. Their results indicate that US equity REITs appear to be more like stocks, rather than direct property. Likewise, Pagliari and Webb (1995) investigate the fundamental return-generating components by using NAREIT and NCREIF data from 1978 to 1994. The results validate that the volatility of direct property was 150% of that of REITs. In contrast, the volatility of REITs was only 25% of that of direct property. The empirical evidence indirectly indicates that REITs do not behave like direct property in the USA.

However, a few scholars in the early 1990s offer different views on the linkage between direct property and REITs. In the US context, Gyourko and Keim (1992) document that lagged REIT returns can predict direct property returns after controlling the persistence in the valuation-based direct property indices. In the US and UK contexts, Barkham and Geltner (1995) examine the linkages between direct property and REITs. They find that direct property returns appeared to lag behind REIT returns by up to two years in the USA and one year in the UK. Jones Lang Wootton (1995) reports the same pattern in the Australian context. These scholars suggest that REITs are more informationally efficient than direct property.

Post-2000 literature has generally reported a strong linkage between REITs and direct property. Glascock *et al*. (2000) find that REITs are co-integrated with the direct property market. Chiang *et al*. (2006) document that the market beta of REIT portfolios appears to converge to that of direct property in the USA from 1993 to 2003. This implies a strong linkage between REITs and direct property in the US context. Clayton and MacKinnon (2003) assess the linkage between REITs and the major financial asset classes in the USA. They find that US-REITs were affected by stocks in the early times. However, US-REITs behaved more like direct properties from 1979 to 1998. Hoesli and Moreno (2006) also observe that REIT returns were positively associated with both stock and direct property returns but negatively related to bond returns from 1990 to 2004. Li *et al*. (2009) adopt the Value at Risk (VAR) analysis and autoregressive conditional heteroskedasticity (ARCH) to scrutinise the dynamic relationship between REITs and direct property. In the VAR analysis, the REIT returns caused direct property returns from 1997 to 2001. Direct property returns were also observed to incorporate information spillover from REIT returns at both the mean and variance levels. In the ARCH analysis, REITs and direct property were shown to have a nonlinear relation. Outside the US property markets, Yong and Pham (2015) examine the relationship between direct property and REITs in Australia from 1985 to 2013. They assess that REITs and direct property were substitutable in both short- and long-term in the Australian context by employing the co-integration test and autoregressive fractionally integrated moving average (ARFIMA). Indirect evidence on the differences between REITs and stocks is also reported by Cotter and Stevenson (2008), Lee and Chiang (2010) and Stevenson (2016).

The strong linkage between REITs and direct property is explained by Hoesli and Oikarinen (2012). They state that both REITs and direct property are affected by the same market fundamentals in both markets. In their study, the US, UK and Australian indices are collected to investigate whether REITs returns can reflect direct property returns or stocks returns based on incorporates economics fundamentals and sector-level property data in the short- and long-run dynamics from 1994 to 2010. The results indicate that REIT returns were closer to the direct property markets compared with the stock markets in the long run. Additionally, REITs returns were found to be independent with no regarding to shocks from direct real estate shocks and stocks across these three markets from 1994 to 2010.

3.2.3 Linkage between Sector-specific REITs and Underlying Property Sectors

To offer a fuller view of the linkage between REITs and direct property, some studies have devoted to the linkage issue at a property sector level. Pagliari *et al*. (2005) analyse the differences between REITs and direct property from three investment perspectives from 1993 to 2001 by using both the mean and volatility data series. These three perspectives are property-type mix, leverage and appraisal smoothing. The research reaches two main findings. Firstly, REITs and direct property should be seen as the same property investment asset on a risk-return basis. Secondly, the platform only matters to the liquidity, governance, transparency, control executive compensation, but not to return characteristics for larger and smaller investors. In short, REIT returns did not differ from direct property returns after controlling appraisal smoothing direct property index. Similar evidence is reported by Riddiough *et al*. (2005), who attempt to adjust property-type, leverage and management fees in order to compare REIT returns and direct property returns in the USA from 1980 to 1998.

Geltner and Kluger (1998), Seiler *et al*. (1999) and Li *et al*. (2009) provide empirical evidence that direct property returns can be predicted by REIT returns by catering the property-type mix. Ling and Naranjo (2015) examine REIT returns and direct property returns at the aggregate level from 1994 to 2012 by considering four property types, namely office, retail, industrial and multifamily. The results illustrate that REITs outperformed direct property on the office and retail sector. At the same time, the multifamily and industrial sectors were on the opposite side. Their study also attempted to control the property type, leverage and management fee, and the results state that there were no statistically significant disparities in REITs and direct property.

At a single property sector level, the relationship amongst retail stocks, retail REITs and retail property is examined by Myer and Webb (1994). A positive contemporaneous relationship between retail REITs and retail stocks is documented after controlling the market returns. In contrast, no positive relationship was discovered for retail REITs and retail property due to overage rents. For the residential sector, Youguo *et al*. (1996) corroborate that residential REIT did not suffer from appraisal-smoothing problems, as well as the volatility of apartment property in the USA from 1982 to 1993. The results indirectly suggest a weak linkage between apartment REITs and apartment property during the early 1990s. Similar evidence is also reported in Malaysia (Lee and Ting, 2011). Pavlov and Wachter (2010) also investigate the relationship between REIT returns and direct property returns at a sub-sector level by considering the market fundamentals. The results show a statistically significant relationship between office REITs and office property. In addition, Cotter and Roll (2015) observe the risk, returns and distributional characteristics of REITs and direct property by using residential REITs and residential property from 1987 to 2009. The results indicate that risk-return attributes of residential REITs were distinct from residential property. Additionally, both residential REITs and residential property were marginally able to predict each other, while there was substantial evidence on self-predictability for both two markets. Hoesli *et al*. (2015) also document that direct property returns could be led by REIT returns in the office and retail property sectors from 1994 to 2010. Nonetheless, direct property returns were unpredictable by REIT returns in the industry and residential property sectors.

More importantly, Hoesli and Oikarinen (2016) find that REITs and direct property were close substitutes in a portfolio from 1994 to 2011. In addition, REIT exchange-traded funds (ETFs) and derivatives were able to hedge the risk associated with mortgage inventory of direct property holdings or lenders. Delfim and Hoesli (2019) examine the role of both REITs and direct property in mixed-asset portfolios in the USA from both open-end core fund and closed-end value-added and opportunistic fund perspectives. They suggest that the efficient portfolio allocation of direct property ranged from 10% to 20% for medium- and long-term investors' portfolios, with REITs used in conjunction with direct investments. Open- and closed-end funds were appropriate investment forms for short-term property investment, rather than the direct investment.

Overall, these two linkage sections have seen the weak linkage between REITs and direct property was documented in the early 1990s, while a stronger linkage between REITs and direct property has been gradually discovered since the 2000s. In other words, REITs are expected to reflect the investment performance of direct property in the longer term. Further, REITs have been validated as a substitute for direct property in mixed-asset portfolios, with greater liquidity, higher transparency, substantial and stable dividend yields, lower transaction costs, reduced performance and cost management structures, and strong portfolio diversification benefits, as well as enjoying the existence of the public markets for property securities (Ooi *et al*., 2006; Horrigan *et al*., 2009; Lee and Ting, 2009; Ong *et al*., 2011; Lee *et al*., 2014; 2018; Newell *et al*., 2015; Sing *et al*., 2016). Importantly, the abovementioned post-2000 literature reports that the strong linkage between REITs and direct property could be well interpreted from the property sector perspectives, as each REIT sub-sectors and the corresponding direct property sector were driven by common market fundamentals.

3.2.4 REIT Investors

As noted by the preceding section, property-related portfolio diversifications are often commenced in REITs by institutional investors, who are not willing to own physical properties (Aguilar *et al*., 2018). Since the US tax legislation included in the Omnibus Budget Reconciliation Act of 1993, modified the fewer role to allow each institutional beneficiary, the level of institutional ownership in REITs has increased dramatically (Stansell and Coffin, 2000; Ciochetti *et al*., 2002; Ghosh and Sirmans, 2003; Lee and Lee, 2003; Chan *et al*., 2005; Hartzell *et al*., 2006; Feng *et al*., 2010, 2011; Chung *et al*., 2012; Devos *et al*., 2013; Aguilar *et al*., 2018; Ling *et al*., 2019; NAREIT, 2019). On top of that, an increased level of passive institutional investor involvement in REITs has been witnessed since REITs became eligible to be included in the S&P indices in 2001 (Aguilar *et al*., 2018). These institutional investors include pension funds, insurance companies, investment companies, bank trust, endowments and foundations. Specifically, institutional ownership of total ownership in REITs increased from 14.14% in 1990 to 75.19% in 2011 (An *et al*., 2016). The debate over the role played by institutional investors in REITs has increased. On the one hand, some scholars argue that institutional investors passively invest in REIT sub-sectors (Bogle, 2009; Aguilar *et al*., 2018). Aguilar *et al*. (2018) report that the level of passive institutional ownership in REITs has twice since 2001 compared with that in direct property. On the other hand, a number of studies observe the strong incentives to control REIT holdings by institutional investors (Feng, 2010; Chung *et al*., 2012). In addition, Below *et al*. (2000) and Ciochetti *et al*. (2002) state that institutional investors prefer to invest in larger and more liquid REITs. By property type, Feng *et al*. (2011) find that office, industrial and residential property sectors had the greatest level of institutional ownership from 1993 to 2009. Lee et al. (2014; 2018) discussed the importance of institutional investors in enhancing market efficiency of REITs.

3.3 REIT ATTRIBUTES BY PROPERTY TYPES

3.3.1 Property Market Fundamentals

REITs have held significant status in the international property investment space, as a well-established listed property investment channel for property investors in the international context. Extensive studies have widely discussed on the investment performance, portfolio diversification benefits, the role in mixed-asset portfolios, the systematic and unsystematic risk (Ooi and Liow, 2004; Liow, 2007; Lee et al., 2007) and volatility spillover effects (Garrigan and Parsons, 1998; Hoesli and Reka, 2013; Liow and Ye, 2014; Lee *et al*., 2017) of composite REITs in recent years.

While composite REITs have attracted primary property investor interest, few studies have focused on individual REIT sub-sectors in respect to the fact that using the overall indices to investigate risk-return characteristics of REITs may diminish the true nature of sector-specific REITs, due to ignoring their own property market fundamentals (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a).

To offer a fuller understanding of various market fundamentals across different property sectors, Wheaton (1999) analyses the cyclicality and oscillations of office, industrial, multi-housing and retail sector in the USA. The results discovered that the asset durability, investment lags, supply or demand elasticities, leases structures and the uses of credit to finance development across various types of property sectors are the main reasons why the market behaviour and investment performance can be fundamentally different across various types of property sectors. In terms of returns, Eichholtz *et al*. (1995) find that returns on distinct property sectors are driven by different economic factors. For instance, office property returns are influenced by office (white-collar) employment, while retail property returns are affected by retail sales, and industrial property returns are changed by manufacturing outputs. Apart from office, retail and industrial properties, residential property returns are associated with the household income and population growth.

In terms of the lease structure, Miles and McCue (1982) find that various types of property sectors act differently because of their distinct lease structures. Specifically, residential properties are leased on a short-term basis, which results in investors suffering from an increased level of vacancy or reduced rentals caused by downturns in the market. Compared with residential properties, office and retail properties are leased on a longer-term basis. However, retail property leases usually include a percentage rent, under which retailers (tenants) pay a portion of annual gross turnover above a stipulated level. This results in retail properties being more volatile than office properties.

In terms of the lease length, Crosby *et al*. (2003) argue that the length of the lease structure varies according to the demand from occupiers. Typically, the space users of office and industrial properties are international or national corporate occupiers who are more concerned over the length of the lease. On the other hand, the space users of retail properties are tenants and consumers, while the occupiers of retail properties are international or national corporate occupiers, as also noted by Benjamin *et al*. (1990). Specifically, the rent-weighted lease length was 14.4 years for retail properties, 10.1 years for industrial properties and 8.9 years for office properties in 2013 (Crosby *et al*., 2006). Despite retail properties having the longest leases amongst all types of properties, the lease length of retailers is commonly based on the short-term (Yuo *et al*., 2011; Yuo *et al*., 2013). On top of the lease length of various types of properties, Crosby *et al*. (2006) suggest that higher market value properties typically have longer leases. Importantly, the term structure of property leases can be substantially impacted by the interest rate risk (Grenadier, 1996, 2005; Clapham and Gunnelin, 2003; Crosby *et al*., 2003, 2006; Ambrose and Yildirim, 2008; Agarwal *et al*., 2011). This can be clarified by the findings of Grenadier (2005), according to which the lease term structure is a function of the expectations of future short-term lease rates, similar to the hypothesis in interest rate term structure models. Specifically, Ambrose and Yildirim (2008) demonstrate that increases in interest rate risk shift the term structure of lease rate upward. However, these results are limited to lease rates for leases of more than five years.

From the property investment perspective, Miles and McCue (1984) propose that institutional investors prefer to allocate office properties and retail properties in their multi-asset portfolios rather than residential properties, which are subject to more management problems, changing tastes and faster physical obsolescence than the other property sectors. Eichholtz *et al*. (1995) not only argue that various types of properties are derived from different macroeconomic factors, but also suggest that the effect of property type mix had a significant impact on the performance of the multi-asset portfolios in the USA. Yavas and Yildirim (2011) argue that previous literature failed to capture the dynamic changes in risk with measuring the volatility and correlations of REITs because it ignored the fact that various types of properties could have distinct risk-return characteristics. Hamelink and Hoesli (2004) investigate the factors of international REIT returns from 1990 to 2003. Their results indicate that property type was a key factor in determining REIT returns, despite country factors being more significant.

Overall, the above studies offer a clear message that commercial property sectors present different risk-return profiles from other sectors, with respect to each property sector featuring different asset durability, investment lags, supply or demand elasticities and lease structures. By using the overall property index, the results may diminish the accurate status of each property sector. Therefore, this study will focus on assessing a differential performance of REIT sub-sectors in the Asia-Pacific.

3.3.2 Segmentation versus Integration

The issue of whether the various property sectors behave differently on a risk-return basis stems from the mainstream finance literature, in which the question of whether the international asset capital market is segmented or integrated has been extensively discussed, without a consensus. The integrated international market has been defined as securities with the same risk characteristics having the same expected returns. Most of the developed markets in the international context have been seen as integrated (Jegadeesh and Titman, 1993; Fama, 1998). In contrast, some studies argue that the international market is actually segmented, since a range of factors – foreign ownership restrictions, information availability, legal and tax differences, exchange rate risks, and other impediments to free flows of capital funds across national borders, such as psychological barriers, legal restrictions, transaction costs, discriminatory taxation, political risk, foreign currency risk – result in securities behaving differently on a risk-return basis. Most emerging markets in the international context have been considered to exhibit a segmentation tend (Errunza and Losq, 1985; Cheng and Glascock, 2005; Tai, 2007; Huyghebaert and Wang, 2010; Wang, 2014).

In the property literature, if property markets are segmented they tend to move in distinct directions in the long run and provide heightened geographic portfolio diversifications for institutional investors (Liu *et al*. 1990a; Ong, 1995, Garvey *et al*., 2001; Wilson and Zurbruegg, 2003a; Bond *et al*., 2003; Gerlach *et al*., 2006). On the other hand, if property markets are integrated they travel in the same direction and provide limited geographic portfolio diversification benefits for investors (Liu and Mei, 1992; Ling and Naranjo, 1999; Glascock *et al*., 2000; Yang *et al*., 2005; Liow, 2008, 2010, 2013; Loo *et al*., 2016).

In the USA, Liu *et al*. (1990a) examine the linkage between the property market and the stocks market in the USA from June 1978 to September 1986. They discover strong evidence of the existence of segmentation in the commercial market and the stock market in the US context. In contrast, Liu and Mei (1992), using a longer timeframe from 1971 to 1989, find that US equity REITs were close to small caps stocks but did not resemble bonds in the USA. Similarly, Ling and Naranjo (1999) document the evidence on integration between the US commercial property and stocks from 1978 to 1994. However, their results fail to support the integration hypothesis after using appraisal-based returns for direct property. Compared with the previous studies, Glascock *et al*. (2000) target REITs and examine the integration of REITs, stocks and bonds. They find that REITs were integrated with stocks and segmented with bonds in the USA after the structural changes in the early 1990s. Apart from the overall property market, Viezer (1999) addresses the issue at the single property sector level by evaluating 51 metropolitan office markets in the USA from 1985 to 1996, using six equations to predict the occupancy, rents, capitalised rates, market value per square foot, net changes in stock and construction cost. The results show that the linkage between real estate space and the capital market could be further strengthened by including interest rates and construction wages.

In Europe, Yang *et al*. (2005) investigate dynamic linkages amongst nine European public property markets, including the UK, France, the Netherlands, France, Belgium, Spain, Switzerland and Denmark. The results indicate that larger property markets in Europe (France, Germany and the Netherlands) were more integrated than those of the other markets. No evidence for this effect was found in smaller economies in Europe (Belgium and Spain). At the same time, little integration was reported for the UK, Switzerland or Denmark. In addition, Liow (2013) examines the interdependence of seven European property securitised markets, namely the UK, France, Germany, the Netherlands, Italy, Sweden and Switzerland, from 1990 to 2011. The results show that these seven property securitised markets were integrated with each other. In particular, Germany was the most volatile market during the GFC period, transmitting conditional volatility to the other markets in the region.

In the Asia-Pacific, Ong (1995) finds no evidence of a contemporaneous long-term relationship between direct property indices and the property stocks in Singapore. Garvey *et al*. (2001) assess the linkage between REITs across Australia, Japan, Hong Kong and Singapore from 1975 to 2001. They find little evidence of co-integration between these REIT markets in the long run, or of casual relationship or volatility spillover for these four markets in the short run. Gerlach *et al*. (2006) report that four major property markets in Asia were firmly integrated with one and the others from 1993 to 2001, despite structural changes in 1997 caused by the Asian financial crisis. Loo *et al*. (2016) explore the linkage between REITs and their respective macroeconomic variables in six Asian markets. The findings indicate that the emerging Asian REIT markets were highly integrated in terms of their macroeconomic variables compared with the developed REIT markets in the region. They suggest that the emerging Asian REIT markets were more sensitive to changes in the marketplace compared with the developed Asian REIT markets.

International evidence has also been reported by global scholars. Liow (2008) finds short- and long-term linkage across the US, UK and Asian listed property markets before, during and after the Asian financial crisis. Stronger market interdependence is found for Asian property securities, particularly for the strong relationship between the USA and Asian markets. Similar evidence was also reported in the findings of Liow (2010), in which the international linkage across the US, UK, Japan and Australian listed property markets strengthened over time. Since the GFC strongly impacted on both the international capital market and the property market, recent studies show an increased level of integration of REITs and stocks during and after the GFC (Liow, 2012; Liow and Schindler, 2014; Liow and Newell, 2016).

Apart from geographic portfolio diversifications, the linkage issue has also been extended to examine sectoral diversifications. Fisher and Liang (2000) use quarterly data for office, retail, industrial, residential properties in the USA from 1978 to 1999. The findings indicate that diversifications by property type were more important than diversifications by geographic region, in line with the findings of Lee (2001), in which UK institutional property portfolios are assessed from 1981 to 1995 using office, retail and industrial properties across 326 locations throughout the UK. The results reinforce that diversifications by property type was much significant that diversifications by geographic region in the UK institutional property portfolios. Newell and Tan (2003) address this issue in assessing Australian institution property portfolios, using office, retail, industrial, hotel, residential property indices from 1995 to 2002. They conclude that both diversifications – by property type and by geographic region – deliver significant benefits, but that diversifications by geographic region outperformed diversifications by property type.

While the integration and segmentation issue has been extensively explored on the international property investment space, no comparable study has been devoted to it from the property sector perspective. This is despite the view that property investment is not a uniform sector within the economy due to the market fundamentals varying between different property sectors. This highlights the importance of assessing risk-return profiles of various REIT sub-sectors in order to highlight the segmentation among different property sectors.

3.3.3 Specialisation Value: REIT Specialised versus Diversified

Recent years have witnessed sector-specific REITs emerging as a major player in the international REIT market. However, diversified REITs dominated the early REIT markets, accounting for 30% of the US-REIT market in 1980 (Pagliari *et al*., 2005). The changing market phenomenon is explained by the findings of Geltner et al. (2014). They state three reasons for the dramatic changes in the REIT markets. Firstly, REIT managers developed more effective management expertise, specialised by property type. Secondly, as REIT investors, particularly institutional investors of the 1990s, intended to make their own diversification decisions, REIT investment strategies shifted from diversified REIT-based portfolios to sector-specific REIT-based portfolios. Lastly, REIT analysts may be able to develop a deeper understanding of REITs by specialising in one market segment.

The effect of specialisation value in the finance literature can explain the comparison of sector-specific and diversified REITs, asserting that a single-business segment trades at a premium over their diversified counterparts (Lemelin, 1982; MacDonald, 1985; Montgomery and Hariharan, 1991; Lang and Stulz, 1994; Berger and Ofek, 1995; Comment and Jarrell, 1995; Silverman, 1999; Delong, 2001; Graham *et al*., 2002; Hyland and Diltz, 2002; Villalonga, 2004; Yao *et al*., 2004). The common theme in the findings of these corporate studies is that investors prefer passive investment vehicles and want firms to do their diversifications, rather than investing themselves in different types of firms. Early corporate finance literature documented the existence of a diversification discount (Lang and Stulz, 1994; Berger and Ofek, 1995; Comment and Jarrell, 1995; Delong, 2001). In addition, Lemelin (1982), MacDonald, (1985), Montgomery and Hariharan (1991) and Silverman (1999) note that diversified business segments are systematically different from a single-business segment. However, recent corporate finance literature has argued against the early diversification discount. Hyland and Diltz (2002) and Villalonga (2004) find evidence that firms operating in multiple business segments were traded at a discount before they diversified into additional business segments. Yao *et al*. (2004) observe hedge fund sector specialists' and sector generalists' exposure to systematic risk. Their results show no difference between sector specialists and sector generalists.

In the REIT literature, Gyourko and Nelling (1996) find that specialised REITs do not offer significant advantages over portfolio diversifications. Chen and Peiser (1999) compare the performance of specialised REITs and diversified REITs. Their results show that there are no statistical differences between the two. Two recent papers investigate the investment performance of REITs and find no evidence of specialised REITs significantly outperforming diversified REITs in the USA (Benefield *et al*., 2009; Ro and Ziobrowski, 2011). Benefield *et al*. (2009) analyse the performance of office, retail, industrial and residential property sectors from 1995 to 2006 in order to examine whether specialised REITs outperformed diversified REITs in the USA. Their findings indicate that diversified REITs outperformed specialised REITs at all time periods. The significant differences were tested between diversified REITs and specialised REITs in the USA. Comparable evidence was also noted by Ro and Ziobrowski (2011), who argue that Benefield *et al*. (2009) failed to control disparities in portfolio compositions, which could bias their findings. Hence, Ro and Ziobrowski (2011) control the impact of a small number of large-size REITs with the use of the empirical analysis on both an equally weighted basis and the more conventional value-weighted basis. Their findings are unexpectedly consistent with those of Benefield *et al*. (2009). The outcomes of Benefield *et al*. (2009) and Ro and Ziobrowski (2011) are in line with the existence of a diversification discount, as acknowledged by the earlier finance literature including Lang and Stulz (1994), Berger and Ofek (1995), Comment and Jarrell (1995) and Delong (2001). Neither the findings of Benefield *et al*. (2009) nor Ro and Ziobrowski (2011) support the assertion of specialised value in the US-REIT market in the pre-GFC context. Chan *et al*. (2003) also denote that specialised REITs could have higher financial costs as its income streams are unstable and coupled with high leverage it may have higher bankruptcy risk. Besides, specialised REIT performed poorly during the downside of a property cycle. Hence, REIT managers are motivated to adopt a diversified strategy. REIT investors view specialised REIT as a less favourable investment during this period.

However, some scholars have proffered different views. Capozza and Seguin (1999) compare the influence of sectoral and geographic diversifications on the REIT value by assessing REIT performance on the basis of cash flows, rather than returns. Their results indicate that a REIT diversified by property type could increase borrowing costs and decrease the value of the REIT firm. Meanwhile, they note that institutional investors intended to actively make their own sectoral diversification decisions. Capozza and

Seguin (1999) also detail the reason expense costs can be heightened by diversified REITs. They observe that both lender and equity investors penalise diversified REITs because of an increased level of information asymmetry, in that the individual property sectors of a diversified REITs may be difficult to value. In other words, an increased level of difficulty in valuing the individual property firm may reduce the transparency and liquidity of diversified REITs. The findings are also documented by Nanda and Narayanan (1999) and Danielsen and Harrison (2007).

In addition, Eichholtz *et al*. (2000) find that specialised REITs outperformed diversified REITs from 1990 to 1996. Simultaneously, Ambrose and Linneman (2001) denote that diversified REITs had the lowest cap rate and profit margins amongst REIT sub-sectors. Morri and Beretta (2008) analyse the leverage, profitability, growth opportunities, size and geographical diversification of REIT sub-sectors from 2002 to 2005. Their findings present that diversified REITs were riskier than specialised REITs. Chong *et al*. (2012) also report a persistent rising correlation between REIT sub-sectors in the USA since the early 1990s.

For the management efficiency, Geltner *et al*. (2014) state that management expertise can be more effective when a REIT portfolio is specialised by property type. This is also supported by Johnson (1999), in which the results document that a REIT portfolio specialising on one property sector can avoid increased management cost. The summary of REIT specialisation value in the previous literature is shown in **Table 3-2**.

Table 3-2: Summary of REIT specialisation value in the previous literature

	Literature	Markets	Time	Analytical techniques	Property sectors	Key findings
1	Gyourko and Nelling (1996)	USA	1990-1992	Systematic market risk, diversification analysis	1, 2, 3, 4, 6	Specialised REITs did not offer significant advantages over portfolio diversifications
2	Capozza and Seguin (1999)	USA	1985-1992	Property rents, cash flows, interest expenses and diversification analysis	1, 2, 3, 4	(1) Expense costs were heightened by diversified REITs; (2) REIT diversified by property type increased borrowing costs and decreased the value of the REIT firm; (3) Institutional investors intended to make their own sectoral diversification decisions
3	Chen and Peiser (1999)	USA	1993-1997	Returns and standard deviation	8	No differences between specialised and diversified REITs
4	Johnson (1999)	USA	1996-1998	Annual reports	1, 2, 3, 4, 5	Specialised REITs avoided increased management cost
5	Eichholtz *et al*. (2000)	USA	1990-1996	CAPM	8	Specialised REITs outperformed diversified REITs
6	Ambrose and Linneman (2001)	USA	1990-1996	CAPM, ROC, ROE, WACC	1, 2, 3, 4, 5, 6	Diversified REITs had the lowest cap rate and profit margins
7	Chan *et al*. (2003)	USA	1962-2002	Literature review	-	(1) Specialised REITs had higher financial costs due to unstable income streams and high leverage; (2) Specialised REIT performed poorly during the downside of a property cycle
8	Danielsen and Harrison (2007)	USA	1993-1995	Pooled time-series model	1, 2, 3, 4, 5, 6	Diversified REITs were less transparent and liquid than sector-specific REITs
9	Morri and Beretta (2008)	USA	2002-2005	OLS	1, 2, 3, 4	Diversified REITs were riskier than specialised REITs
10	Benefield et al. (2009)	USA	1995-2006	Return measures	8	Diversified REITs outperformed specialised REITs
11	Ro and Ziobrowski (2011)	USA	1997-2006	CAPM and Fama-French model	8	Diversified REITs outperformed specialised REITs
12	Chong *et al*. (2012)	USA	1990-2008	Diversification analysis	1, 2, 3, 4, 5, 6	Rising correlation between REIT sub-sectors since the early 1990s
13	Geltner et al. (2014)	USA	1967-2004	Literature review	-	Management expertise was more effective when REITs are specialised by property type
14	Lin *et al*. (2019a)	Australia	2000-2018	Performance and diversification, portfolio analyses	1, 2, 3, 4, 7	Sector-specific REITs outperformed diversified REITs
15	Lin *et al*. (2019b)	Japan	2006-2018	Performance and diversification, portfolio analyses	1, 2, 3, 4, 7	Sector-specific REITs outperformed diversified REITs

Source: Author's compilation; **Note:** 1: office; 2: retail; 3: industrial; 4: residential; 5: lodging; 6: healthcare; 7: specialty; 8: specialised REIT portfolio

Overall, this section has illustrated that various types of property sectors exhibit different risk-return attributes from each other, since each property sector features distinct asset durability, investment lags, supply or demand elasticities and lease structures. In addition, despite specialisation offering a higher level of flexibility and displaying as the favoured REIT structure among investors, it is unclear whether sector-specific REITs offer enhanced portfolio diversification benefits or increased portfolio returns. Some US-REIT studies discovered evidence against the assertion of REIT specialisation value (Benefield *et al.*, 2009; Ro and Ziobrowski, 2011). Nonetheless, these studies mostly investigate US-REITs, and no international study is available to validate the REIT specialisation value. Given an adverse impact of the GFC upon the REIT markets (Kim, 2009; Newell and Razali, 2009; Peng and Lee, 2013; Lee *et al.*, 2016), it is imperative to offer international evidence on REIT specialisation value after the GFC. More importantly, unlike previous studies that, by taking different property types of REITs as a hybrid specialised REIT portfolio, disregard the fact that various property sectors characterise distinct market cycles (Miles and McCue, 1982; Eichholtz *et al.*, 1995; Wheaton, 1999; Crosby *et al.*, 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Hoesli and Oikarinen, 2012, 2016; Geltner *et al.*, 2014; Hoesli *et al.*, 2015; Lin *et al.*, 2019a), this study compares different property types of REITs with diversified REITs in terms of risk-adjusted performance, portfolio diversification benefits, roles in mixed-asset portfolios and sensitivity to interest rate changes. These have comprehensive insights for property investors seeking listed property exposure in the Asia-Pacific.

3.4 OVERVIEW OF REITs IN THE ASIA-PACIFIC

While direct property still has some investment weaknesses, such as the large investment required, relatively low liquidity, the smaller number of market participants, high transaction costs, the need for local knowledge, and management burdens (Seiler *et al.*, 2001; Wilson and Zurbruegg, 2003b), REITs have been seen as a well-established listed property investment channel to overcome these drawbacks for local and international investors, particularly institutional investors. The significance of REITs has attracted international scholarly attention to REIT investment strategies (Ooi and Liow, 2004; Ooi *et al.*, 2006; Hoesli *et al.*, 2008; Horrigan *et al.*, 2009; Ong *et al.*, 2011; Yavas and Yildrim, 2011; Newell *et al.*, 2015; Sing *et al.*, 2016; Lee *et al.*, 2017).

3.4.1 Performance and Portfolio Diversification Benefits of Composite REITs

3.4.1.1 USA and Europe

As the largest and longest-established REIT market in the international context, the US market has attracted international scholarly attention to REIT investment strategies. In particular, the National Association of Real Estate Investment Trusts (NAREIT), an association representing the REIT market in the USA, offers robust data on various property types of US-REITs for practitioners and scholars with interests in the US-REIT market.

The pre-2000 literature offered conflicting evidence on whether composite US-REITs outperformed the market benchmark. The research of Smith and Shulman (1976), Burns and Epley (1982) Liu *et al*. (1990b), Chan *et al*. (1990), Glascock and Hughes (1995), Han and Liang (1995) find that US-REITs offered higher or comparable investment performance compared with the market benchmark. On the other hand, inferior investment performance for composite US-REITs in comparison with the benchmark is reported by Howe and Shilling (1990), Peterson and Hsieh (1997) and Chen and Peiser (1999). Yong (2000) finds that the average monthly returns of different REIT sub-sectors were integrated. The results imply that a portfolio with different REIT sub-sectors could offer less portfolio diversifications. The contradictory results may be attributed to different timeframes, survivorship bias or inappropriate REIT index use, noticed by Sagalyn (1990) and Han and Liang (1995).

Recent literature reports superior investment performance (Pagliari *et al*. 2005; Lee *et al*., 2012; Lee *et al*., 2014; Ling and Naranjo, 2015; Ling *et al*., 2016; Marzuki and Newell, 2017; Moss, 2018) and portfolio diversification benefits (Fisher and Liang, 2000; Chen, 2007; Case *et al*., 2010) for composite US-REITs compared with the market benchmark. It is noteworthy that a positive relationship between composite REITs and stocks was documented in the early 1990s (Liu *et al*. 1990a; Ambrose *et al*. 1992; Liu and Mei, 1992; Myer and Webb, 1994; Fisher *et al*.,1994; Brueggeman and Fisher, 1997; Mull and Soenen, 1997). However, since the strong linkage between composite REITs and direct property was explored in the post-2000 literature (Glascock *et al*., 2000; Chiang *et al*., 2006; Li *et al*., 2009), stronger portfolio diversifications by property type and geography of composite US-REITs has gradually been discovered (Fisher and Liang, 2000; Lee, 2001; Newell and Tan, 2003; Chen, 2007; Case *et al*., 2010; Leone and Ravishankar, 2018). Importantly, the findings of Stevenson (2002) indicate that the persistence and predictability of composite REITs could be useful to property mutual fund managers.

In Europe, scholars have recently assessed the portfolio diversification benefits and risk-return attributes of composite REITs in the UK compared with the market benchmark (Kovac and Lee, 2008; Newell and Marzuki, 2016), France (Newell *et al*. 2013), Germany (Lachner and Heppe, 2006; Newell and Marzuki, 2018), Belgium (Marzuki and Newell, 2019b), Spain (Marzuki and Newell, 2018) and Ireland (Marzuki *et al*., 2020), as well as the inflation hedging effectiveness of composite REITs in Europe (Lee and Lee, 2014).

In the international context, Serrano and Hoesli (2010) offer a comparison of the predictability of REITs and stocks across ten countries from 1990 to 2007, including the USA, the UK, France, the Netherlands, Germany, Sweden, Japan, Australia, Singapore and Hong Kong. The findings confirm that REIT returns were more predictable than returns on stocks in countries with mature and well-established REITs regimes.

3.4.1.2 Japan

Within the J-REIT research, research interest has focused on investment performance (Newell and Peng, 2012; Cho, 2017; Lee, 2018), initial public offerings (Kutsuna *et al*., 2008; Ma and Michayluk, 2015), debt raising and refinancing strategies (Tang *et al*., 2016), the capability to track direct property prices (Shimizu *et al*., 2015), debt raising and refinancing (Tang *et al*., 2016) and wealth effect on property acquisitions (Ooi *et al*., 2011) of composite J-REITs, as well as the hedging effectiveness of J-REIT futures (Lee and Lee, 2012). Newell and Peng (2012) investigated the returns, risk, and risk-adjusted returns of composite J-REITs between 2001 and 2011. The findings provide strong evidence that composite J-REITs offered the best risk-adjusted returns amongst all assets in Japan during the study period. At the same time, attractive diversification benefits with both stocks ($r = 0.58$) and bonds ($r = -0.02$) were recorded for composite J-REITs.

The role of composite J-REITs has also been widely discussed in the Asian and international REIT contexts (Yunus and Swanson, 2007; Su *et al*., 2010; Liow, 2008, 2012;

Kim, 2009; Chang *et al*., 2012; Peng and Lee, 2013; Loo *et al*., 2015, 2016; Tang and Mori, 2017; Ooi *et al*., 2018; Liow *et al*., 2019a, b). Yunus and Swanson (2007) explore the linkage between the US and Asia-Pacific REIT markets (Japan, Australia, Singapore and Hong Kong) from 2000 to 2006. The results indicate that there was no significant integration between US-REITs and Asia-Pacific REITs. Therefore, they suggest that Asia-Pacific REITs could deliver greater portfolio diversification benefits to international property investors in the USA.

Kim (2009) uses the co-integration test and error correction model to examine composite REITs in South Korea, Japan, Australia and the USA from 2004 to 2009, finding that composite J-REITs suffered a weak effect from composite US-REITs compared with the effect in other markets. However, composite J-REITs had a stronger relationship with that in the USA after the GFC. Peng and Lee (2013), employing the ARMAX-GJR-GARCH copula and time-varying dynamic copula models, argue that the GFC had a significant impact on the J-REIT market from 2005 to 2011.

3.4.1.3 Australia

As one of the longest-established REIT markets in the international context, the significance of A-REITs investment strategies has attracted significant attention (Newell and Tan, 2005; Lee *et al*., 2007; Dimovski, 2010; Newell, 2010a, b; Newell *et al*., 2011; Newell and Lee, 2012; Reddy, 2012; Reddy *et al*., 2013; Reddy *et al*., 2014; Lee, 2018).

A-REITs have been viewed as a successful listed property investment channel for Australian fund managers after the GFC (Newell and Peng, 2009; Newell and Razali, 2009; Newell and Lee, 2012; Reddy, 2012). They deliver heightened portfolio returns in a multi-asset portfolio (Reddy *et al*., 2013). The scale of the capital raised by A-REITs soared after the GFC due to the market's strong recovery from the GFC (Dimovski and O'Neill, 2012). Chikolwa (2009) uses panel data analysis to examine the determinants of A-REITs from 2000 to 2008. The results show that the profitability, growth and operational risk of A-REITs had negative effects on the level of A-REIT leverage. However, the size of A-REITs had a positive influence on the investment performance of A-REITs.

Several studies examine the risk of A-REITs. For example, Lee *et al*. (2008b) examine and identify A-REIT systematic risk, while, Lee (2008) and Yong and Pham (2015) examine the relationship between direct property and A-REITs. Lee *et al*. (2016) assess the volatility transmission of A-REITs. Last but not least, Newell (2010b) and Lee (2009) examine the performance and trading of the A-REIT futures market from August 2002 to November 2009 from the institutional investor perspective. Newell and Lee (2012) explore the effect of the corporate social responsibility on the investment performance of composite A-REITs.

3.4.1.4 Singapore

Newell *et al*. (2015) assess the return and risk profiles of composite S-REITs using monthly total return data from 2003 to 2013, sourced from FTSE ST. The strong risk-adjusted performance of composite S-REITs compared with the mainstream asset classes in Singapore was reported over the study period. However, the results suggest that composite S-REITs provided less portfolio diversification benefits than stocks and property companies in Singapore, as the correlations with stocks and property companies for composite S-REITs were 0.84 and 0.70, respectively.

Other aspects of composite S-REITs have also been extensively discussed, such as the share ownership structure (Kudus and Sing, 2011), issuance (Ong *et al*., 2011), corporate governance (Lecomte and Ooi, 2013), compensation structure (Ooi, 2009) and wealth effect on property acquisitions (Ooi *et al*., 2011). For example, Ong *et al*. (2011) employ cross-sectional OLS regression to examine the influence of both market conditions and asset acquisitions on Seasoned Equity Offerings (SEOs) made by composite S-REITs from 2002 to 2007. The findings show that S-REITs were likely to issue equity in the high and increasing debt level.

Composite S-REITs have been widely discussed alongside other REIT markets in the Asian and international REIT contexts (Ooi *et al*., 2006; Yunus and Swanson, 2007; Liow, 2008; Liow and Adair, 2009; Liow, 2012; Liow and Chen, 2013; Loo *et al*., 2015; Ooi *et al*., 2018; Liow *et al*., 2019a, b). For instance, Liow (2008) illustrates the changing linkages among US, UK, and Asian REIT markets (Hong Kong, Japan, Indonesia, Malaysia, Philippines, Singapore and Thailand) in the short and long run, particularly before, during and after the Asian Financial Crisis. The findings indicate that market interdependence in the Asian REIT markets became stronger, in both the short and long term, since the Asian Financial Crisis. Loo *et al*. (2015) investigate the linkages among the Asian REIT markets over the short and long term before, during and after the GFC, using the co-integration test and causality test on data from 2006 to 2014. They discover that Asian REITs had strong co-integration each other in the short term, but did offer appealing portfolio diversification benefits for international property investors seeking listed property exposure in Asia. The findings also indicate that Asian REITs were affected by national economic linkages and geographic locations in both the emerging REIT markets and developed REIT markets in Asia. The developed REIT markets in Asia had a strong influence on the regional REIT market over the post-GFC period. In particular, the Singapore REIT market controlled the short-term effect in the region over the study period.

3.4.2 Role of Composite REITs in Mixed-asset Portfolios

3.4.2.1 USA and Europe

As REITs are expected to reflect the investment performance of direct property in the longer term, the role of REITs in mixed-asset portfolios has been the focus of intense and rigorous empirical examination. In the USA, Kuhle (1987) authores the initial study on the issue and shows that the inclusion of composite US-REITs failed to enhance returns of stock-only portfolios. Mull and Soenen (1997) examine the role of composite US-REITs in international mixed-asset portfolios in G7 countries (the USA, UK, Germany, France, Canada, Japan and Italy) from 1985 to 1994. The results indicate that the addition of composite US-REITs did not provide performance enhancement in portfolios in all countries, except for the UK and Canada. Similar results are documented by Paladino and Mayo (1998) and Capozza and Sequin (1999).

In contrast, Burns and Epeley (1982) find that a portfolio containing a certain percentage of composite US-REITs and stocks can outperform a pure stock-only portfolio. Subsequent studies by Mueller *et al*. (1994) validate these results, finding the addition of composite US-REITs would increase additional portfolio returns by between 1% and 14% basis points per month or 12% and 168% per annum. More specifically, the efficient portfolio allocations of composite US-REITs were 14% at the lower end, 82% at the medium point and 3% at the higher end. Comparable evidence is reported by Youguo *et al*. (1996), with the efficient portfolio allocation of both US equity REITs and residential REITs being weighted at from 15% to 20% from 1982 to 1993. Examining the risk level of REIT portfolios, Liang *et al*. (1995) find the changes in risk of four REIT portfolios in the USA from 1973 to 1989, including an all-REIT portfolio, an equity REIT portfolio, a hybrid REIT portfolio and a mortgage REIT portfolio.

Post-2000 studies gradually documented the results of the inclusion of composite REITs in enhancing portfolio returns. Mueller and Mueller (2003) state that composite US-REITs were a significant contributor to mixed-asset portfolios over a 25-year study period. Feldman (2003) finds that the optimal portfolio allocation in composite US-REITs lies between 12% and 13%. Likewise, Lee and Stevenson (2005) investigate the role of composite US-REITs in multi-asset portfolios in 5, 10, 15 and 20-year holdings period since 1984. The researchers explore whether composite US-REITs could offer an enhanced portfolio return and reduced portfolio risk level across all the holding periods. Case *et al*. (2010) find an optimal portfolio allocation for both composite REITs and direct property of between 17% and 42% in mixed-asset portfolios from 1972 to 2008. Furthermore, the results indicate that the role of composite US-REITs was more important for longer portfolio holding periods. A higher optimal portfolio allocation of composite US-REITs, weighted at 44.1%, is suggested by the findings of Marzuki and Newell (2017).

In Europe, composite UK-REITs are reported as an added-value role in UK optimal and constrained mixed-asset portfolios from 2009 to 2014 in the findings of Newell and Marzuki (2016). Farrelly and Moss (2014) investigate the role of both composite REITs and direct property in UK mixed-asset portfolios from 1998 to 2003. The results suggest that a portfolio allocation of composite REITs weighted at 30% could enhance portfolio returns by 1%. On the other hand, a 0.2% portfolio allocation to direct property could increase portfolio returns by 5%. Similar results are also documented for composite REITs in France, Germany, Belgium, Spain and Ireland in their respective domestic mixed-asset portfolios, particularly in the post-GFC context (Newell *et al*., 2013; Newell and Marzuki, 2018; Marzuki and Newell, 2018, 19; Marzuki *et al*., 2020). Moss and Farrelly (2015) investigate property allocation in a UK Defined Contribution (DC) pension fund from 1998 to 2013. The findings refer to a blended property portfolio with 30% listed property allocation via a Global REIT tracker fund. The recent findings of Ametefe *et al*. (2019) also suggest that the addition of listed property via REITs in blended property portfolios enhanced returns, with liquidity benefits from a UK DC pension fund perspective. The constrained blended or hybrid property portfolios allocated significant portfolio compositions to the listed property via REITs, stocks and bonds from 1987 to 2015. Haran *et al*. (2013) examine the role of composite REITs in mixed-asset portfolios compared with direct property across the USA, UK, Australia, France, the Netherlands, Germany and Sweden from 2002 to 2011. They suggest that a blended property investment strategy, which includes both REITs and direct property, could heighten portfolio returns.

In the international context, Moss *et al*. (2015) investigate risk-adjusted returns of a global REIT portfolio from 1991 to 2014. Their findings show that a global REIT strategy could be beneficial for both a REIT portfolio and the inclusion of REITs in mixed-asset portfolios over the study period.

3.4.2.2 Japan

While the Japan REIT market has been one of the largest REITs in the international context, few studies have investigated the role of composite J-REITs in mixed-asset portfolios. Chiang *et al*. (2008) investigate the role of composite REITs in Japan and Singapore in multi-asset portfolios with the addition of stocks, bonds and direct property. They report that REITs should not be seen as a substitute for direct property in mixed-asset portfolios, despite that REITs could offer strong portfolio diversification benefits.

Newell and Peng (2012) conduct an analysis examining the role of composite J-REITs in a mixed-asset portfolio in Japan compared with property companies from 2001 to 2011, with the sub-period analysis focusing on the impact of the GFC on the investment performance of composite J-REITs. Using monthly total return data, the results indicate that the inclusion of composite J-REITs could heighten portfolio returns. Composite J-REITs played a stronger role than property companies in mixed-asset portfolios in Japan. Following the GFC, composite J-REITs was the only property asset class in the Japan multi-asset portfolio.

3.4.2.3 Australia

Tan (2004a, 2004b) examines the role of composite A-REITs in Australian multi-asset portfolios compared with direct property from 1997 to 2003. The results indicate that composite A-REITs offer significant portfolio diversification benefits in mixed-asset portfolios. Further, the constrained portfolio allocations of composite A-REITs and direct property were weighted at 10% and 20%, respectively.

Newell (2010) highlights that the inclusion of A-REIT futures in A-REIT portfolios helped A-REIT institutional investors hedge A-REIT exposure during the GFC, including in September 2007, December 2007 and September 2008. From the Australian superannuation fund perspective, Reddy *et al*. (2013) adopt nine asset allocation models to examine the role of both composite A-REITs and direct property in mixed-asset portfolios from 1995 to 2011. The findings show that the optimal portfolio composition of both composite A-REITs and direct property was weighted between 5% and 16%, which could have significantly improved portfolio returns for Australian superannuation funds over the study period.

3.4.2.4 Singapore

Newell *et al*. (2015) examine the role of composite S-REITs in Singapore mixed-asset portfolios compared with property companies and the mainstream asset classes from 2003 to 2013. Using monthly data, the optimal and constrained portfolio results show that composite S-REITs played a prominent role in the optimal portfolio and were the main contributor to the constrained property allocations. They also perform a sub-period analysis to strengthen the added-value role of composite S-REITs in mixed-asset portfolios. The findings indicate that composite S-REITs played a stronger role in the pre-GFC mixed-asset portfolio compared with post-GFC performance. Similar findings are documented by Wong and Tong (2011).

Apart from Japan, Australia and Singapore, some scholars have explored the role of composite REITs in mixed-asset portfolios in Hong Kong (Newell *et al*., 2010), Malaysia (Newell *et al*., 2002; Sing *et al*., 2002; Lee *et al*., 2008a; Lee and Ting, 2009; Newell and Osmadi, 2010; Kien and Kuan, 2011), Taiwan (Peng and Newell, 2012; Lee *et al*., 2011), Thailand (Pham, 2011b) and South Korea (Pham, 2011a).

3.5 OVERVIEW OF SECTOR-SPECIFIC REITs IN THE ASIA-PACIFIC

3.5.1 Performance and Portfolio Diversification Benefits of Sector-specific REITs

3.5.1.1 USA and Europe

At a single-sector level, numerous REIT scholars have reported risk-return profiles and investment strategies of individual REIT sub-sectors in the international context. In the USA, office and retail REITs have been widely used to compare with other REIT sub-sectors on an investment performance basis (Miles and McCue, 1982; Neil and Webb, 1994; Capozza and Korean, 1995; Gyourko and Neiling, 1996; Chen and Peiser, 1999). Miles and McCue (1982) investigate the performance of office, retail and residential REITs in both REIT portfolios and Commingled Real Estate Funds (CREs) portfolios in the USA from 1972 to 1978. The findings illustrate that residential REITs delivered higher portfolio diversification benefits than either office or retail REITs. Neil and Webb (1994) find a negative relationship between office REITs and office stocks in the USA. Additionally, their study finds that retail REITs and retail property had no positive relationship in the USA. However, a positive relationship between retail REITs and retail stocks is found in their results. Capozza and Korean (1995) report that retail REITs was traded at a significant premium compared with office, industrial and residential REITs in the USA. Mueller and Laposa (1996) examine historical return series for office, retail, industrial, residential, self-storage and healthcare REITs in the USA from 1972 to 1995. They find that all REIT sub-sectors moved similarly from 1972 to 1985, while these REIT sub-sectors diverged from 1985 to 1995. Gyourko and Neiling (1996) deliver some interesting findings that retail REITs possessed a higher beta than industrial REITs in the USA from 1988 to 1992. Chen and Peiser (1999) note the superior performance of office and industrial REITs compared with other REIT sub-sectors in the USA.

For industrial REITs, Capozza and Korean (1995) note that industrial REITs was traded at a discount in comparison with office, retail and residential REITs. In addition, their results show that small REITs traded at a larger discount, while large REITs traded at a premium. Lin *et al*. (2020) reveal the market phenomenon of industrial REITs moving from traditional industrial property structures to logistics property formats in the post-GFC context, as industrial and logistics (I&L) REITs. The findings indicate that I&L

REITs registered the highest average annualised returns amongst all asset classes in the USA from July 2011 to December 2018, at 11.74%, with the highest annual risk level at 20.33%. Additionally, they report that I&L REITs presented the least diversification benefits with US stocks amongst all REIT sub-sectors in the USA. Nevertheless, I&L REITs offered desirable diversification benefits with bonds in the USA.

For residential REITs, He (2000) documents a strong positive contemporaneous causal relationship between residential REITs and residential property. The results suggest that these two assets responded to some fundamental changes, such as interest rates movements. Ambrose et al. (2000) find that geographic specialisation could not enhance the NOI growth of 41 residential REITs between 1990 and 1997. Newell and Fischer (2009) compare the investment performance and portfolio diversification benefits of residential REITs and the other REIT sub-sectors in the USA by using quarterly data from 1994 to 2007. The results indicate that residential REITs generally provide a lesser average annual return, lower annual risk and weaker diversification benefits with stocks than the other REIT sub-sectors, such as office, retail and industrial REITs. Using recent data, Cotter and Roll (2015) show that residential REITs was less risky than stocks in the USA. Additionally, neither residential REITs nor residential property were able to predict each other, but there was substantial evidence of self-predictability for these two assets.

Lodging REITs have attracted scholarly interests in the US context. Kim *et al*. (2002) claim that lodging REITs was more volatile than other REIT sub-sectors. Jackson (2009) reports that lodging REITs offered poorer investment performance than other REIT sub-sectors but superior investment performance to retail and specialty REITs from 1993 to 2005. The systematic and unsystematic risks of hotel REIT stocks from 1993 to 1999 were investigated by Kim *et al*. (2002), who found 84% of the total risk for lodging REITs was contributed by firm-specific, unsystematic risk. They note that growth via mergers and acquisitions and less reliance on debt financing may help decrease systematic risk and enhance lodging REITs' value. Similar evidence is reported by Gu and Kim (2003). The relationship between lodging REITs and hotel property is also investigated by Mooradian and Yang (2001), Oak and Dalbor (2008) and Kim and Jang (2012). Both lodging REITs and hotel property with similar risk-return profiles during the 2000s are reported by Kim and Jang (2012).

For the other REIT sub-sectors, literature documents risk-return profiles and investment strategies of timberland (Newell and Eves, 2009; Piao *et al*., 2016), data centre (Marzuki and Newell, 2019a) and infrastructure REITs (Newell and Peng, 2008; Marzuki and Newell, 2020). Marzuki and Newell, 2019a (2019) find that data centre REITs delivered comparable performance and superior risk-adjusted returns to composite REITs in the USA from 2016 to 2018. In Europe, García-Lamarca (2020) reports that Spanish residential REITs reinforce socio-spatial urban inequality and dispossession.

3.5.1.2 Japan

There are limited studies devoted to the investment performance and portfolio diversification benefits of REIT sub-sectors in Japan. Cho (2017) examines the significance, risk-adjusted returns and portfolio diversifications of all REIT sub-sectors in Japan from 2010 and 2015. The results indicate that the non-traditional REIT sector (lodging REITs) offered higher risk-adjusted performance and more substantial diversification benefits with mainstream asset classes compared to the traditional REIT sector (office, retail, residential REITs). For office REITs, Newell *et al*. (2009) investigate risk-adjusted returns and portfolio diversifications of office REITs in Tokyo (International Financial Centres, IFC) from 1998 to 2008. Both the major IFC markets and the non-IFC markets in Japan deliver effective portfolio diversification benefits in Asian property portfolios.

For recent industrial REITs, Lin *et al*. (2020) observe that industrial REITs replaced traditional industrial properties with logistic properties to capture strategic exposure to recent e-commerce trends, and assess risk-adjusted returns and portfolio diversifications of I&L REITs from July 2011 to December 2018. The results indicate that I&L REITs delivered the second-highest average annualised returns among all assets in Japan, with the lowest annual risk amongst all REIT sub-sectors in Japan. Additionally, I&L REITs offered higher diversification benefits with stocks than the other REIT sub-sectors in Japan. In terms of portfolio diversification benefits with bonds, I&L REITs was weakly correlated with bonds ($r = 0.16$). The findings highlight substantial diversification benefits with the mainstream asset classes for I&L REITs in Japan.

For residential REITs, Lin *et al*. (2019b) argue for the effectiveness of residential J-REITs in a mixed-asset portfolio context in Japan by assessing the significance, risk-adjusted returns and portfolio diversifications of residential J-REITs from July 2006 to August 2018. The findings show that residential J-REITs generally delivered superior risk-adjusted returns compared with the other sub-sector J-REITs, stocks and bonds in Japan, with desirable portfolio diversification benefits in mixed-asset portfolios.

3.5.1.3 Australia

As one of the most transparent property markets in the international context, scholarly interests in the Australian REIT sub-sector markets have increased in recent years. Newell (2006) observes an increased level of risk for all REIT sub-sectors from 2003 to 2004, as well as the correlations with stocks in Australia. These REIT sub-sectors included office, retail, industrial REITs. Chikolwa (2009) reveals the determinants of capital structure for all REIT sub-sectors in Australia. The results show that office REITs had insignificant negative results with leverage and retail while industrial REITs with a high level of income streams were able to afford higher levels of debt. In general, the findings suggest that all REIT sub-sectors had a positive influence on leverage from 2003 to 2008. Focusing on the REIT specialisation value in Australia, Lin *et al*. (2019a) compare different property types of REITs with diversified REITs. The analysis assessed risk-return returns, portfolio diversifications and portfolio allocation strategies for sector-specific REITs in Australia since January 2000. The findings indicate that different property types of REITs provided higher risk-adjusted returns than diversified REITs, as well as having more attractive portfolio diversifications than both the mainstream asset classes in Australia. More importantly, they confirm that sector-specific REITs are empirically distinct from diversified REITs in the Australian REIT context, reinforced by the sub-period analysis, consisting of the pre-GFC and post-GFC periods.

For retail REITs, Newell and Peng (2007a) examine the investment performance of retail REITs and the significance of retail property type, size and region to retail REITs in Australia from 1995 to 2005. They report attractive risk-adjusted performance for retail REITs. Additionally, they document that retail REITs was weakly correlated with stocks (r = 0.14) and bonds (r = 0.44) in Australia over the study period.

For lodging REITs, the findings of Newell and Pend (2007b) indicate that lodging REITs outperformed other REIT sub-sectors in Australia on a risk-adjusted return basis from 2000 to 2006. At the same time, lodging REITs offered attractive portfolio diversifications with both the mainstream asset classes and other REIT sub-sectors. They suggest that lodging REITs should not be considered as a sub-sector of retail property.

For infrastructure REITs, Peng and Newell (2007) introduce listed infrastructure funds and companies in Australia and investigate their investment performance from 1995 to 2006, including five toll roads, nine transmission and distribution facilities, three integrated utilities, two airports, one communication utility, one diversified utility and 11 generation utilities. The results show that infrastructure REITs offered the highest average annual returns among all asset classes in Australia, as well as providing higher volatility than the other assets. In short, they document acceptable portfolio diversification benefits offered by these infrastructure sectors.

3.5.1.4 Singapore

Few studies have devoted to the Singapore REIT market at a single REIT sub-sector level. Sing and Ling (2003) simulate ex-post returns for diversified, office, retail and industrial Hypothetical Property Trusts (HPTs) in Singapore from 1995 to 2002 by employing downside risk in the asset allocation framework. The results show that retail HPTs delivered the highest returns of all HPT sub-sectors. Nonetheless, both office and industrial HPTs had the lowest relationship with stocks. In addition, office, retail and industrial HPTs could diversify the idiosyncratic risk of financial asset-only portfolios over the study period. Ho *et al*. (2013) examine the effect of green developments on S-REIT returns at a single sector level from 2007 to 2011. The findings show that the effect varied across different REIT sub-sectors, such as office, retail, industrial and specialty REITs. For office REITs, Newell *et al*. (2009) target the investment performance of IFC in Singapore from 1998 to 2008 by employing office REITs in Singapore. Strong portfolio diversification benefits for IFC in Singapore were found for global investors in the Asian markets.

Lin *et al*. (2019b) observe the market phenomenon whereby industrial REITs have moved from traditional industrial property structures to logistics property formats in the post-GFC context, and assess risk-adjusted returns and portfolio diversifications of I&L REITs from July 2011 to December 2018. The results show that I&L REITs was the top best-performing assets in Singapore investment context, since they delivered high annual returns but a lower risk level than other REIT sub-sectors and mainstream asset classes. In terms of portfolio diversification benefits with stocks, I&L REITs was superior to other REIT sub-sectors. Also, I&L REITs offered attractive diversification benefits with bonds, evident by the negative correlation (−0.33) of bonds with I&L REITs.

Other specialised REIT asset, such as Islamic REITs, have also attracted international scholars attention (Newell and Osmadi, 2009; Razali and Sing, 2015; Chuweni *et al*., 2017).

3.5.2 Role of Sector-specific REITs in Mixed-asset Portfolios

3.5.2.1 USA

The role of REIT sub-sectors in mixed-asset portfolios has been a heated issue in the international investment context in recent years. Miles and McCue (1982) examine the performance of office, retail and residential REITs in both REIT portfolios and Commingled Real Estate Funds (CREs) portfolios in the USA from the pension fund perspective from 1972 to 1978. The results indicate that the optimal REIT portfolio allocations were to office (average allocation = 21.8%), retail (23.6%), industrial (2.3%) and residential REITs (28.1%) over the study period. In commingled real estate fund (CREF) portfolios set up by insurance companies, commercial banks and capital management companies, residential REITs contributed on average 49.0%, followed by office and retail REITs (47.5%), and industrial REITs (3.6%). The authors conclude that the CREF portfolio could offer attractive portfolio diversification benefits by investing in REITs, despite the fact that CREFs generally hold portfolios comprising short-term REITs and direct property.

For office REITs, Freybote and Seagraves (2017) found that institutional investors, such as commercial banks, insurers, pension funds, relied exclusively on their institutional sentiment in the US office REIT market in multi-asset portfolios, particularly for an office REIT portfolio comprising office properties in the CBD. For industrial REITs, the added-value role of I&L REITs in a US constrained mixed-asset portfolio from July 2011 to December 2018 was confirmed by the findings of Lin *et al*. (2020). The results show that

I&L REITs coexisted with both stocks, bonds and residential REITs in the constrained multi-asset portfolio over the study period. They conclude that I&L REITs in the USA can provide effective I&L property exposure in the USA in order to capture strategic exposure to recent e-commerce trends. The results are underpinned by several portfolio analyses, including the Pacific Rim-based portfolio, downside risk portfolio and regional I&L REIT portfolio.

For residential REITs, Youguo *et al*. (1996) state that residential REITs could be a substitute for residential property in mixed-asset portfolios in the USA. Their results show that the efficient portfolio allocations for both US equity REITs and residential REITs were weighted at 15% to 20% from 1982 to 1993. Regardless of lodging REITs or hotel property, Oak and Dalbor (2008) discovered that institutional investors, such as mutual funds and pension funds, preferred large-scale lodging REITs in their multi-asset portfolio holdings, given investment in the hospitality industry by institutional investors has increased rapidly since the 1990s.

A significant role of timberland, data centre and infrastructure REITs in mixed-asset portfolios in the USA is documented in the findings of Newell and Peng (2008), Newell and Eves (2009), Marzuki and Newell (2019a) and Marzuki and Newell (2020). Data centre REITs accounted for a maximum 20% of constrained total property composition in the US mixed-asset portfolio from 2016 to 2018, as noted by Marzuki and Newell (2019a). Within the 20% constrained total property allocation, both listed satellite and telecommunication infrastructure REITs reached a maximum level of 5% from 2009 to 2019, as documented by Marzuki and Newell (2020).

3.5.2.2 Japan

Cho (2017) investigates the role of all REIT sub-sectors in mixed-asset portfolios in Japan from 2010 to 2015. The results indicate that lodging REITs was the highest contributor to the Japan mixed-asset portfolio compared with stocks, bonds, property companies and unlisted property funds over the study period, as they offered higher annual returns and lower risk level. For industrial REITs, I&L REITs accounted for a maximum of 2.8% of the capped total property exposure in mixed-asset portfolios from July 2011 to December 2018. Meanwhile, office, retail and residential REITs played no role in the total constrained portfolio allocation. The findings are strengthened by several robustness checks, such as the Pacific Rim-based portfolio, downside risk portfolio and regional I&L REIT portfolio.

For residential REITs, Lin *et al*. (2019b) document that the optimal portfolio allocation in residential REITs was on average 12.8%, embedded across the broad risk-return band of Japan mixed-asset portfolios from July 2006 to August 2018. In particular, residential REITs (an average allocation = 14.9%) dominated the broad risk-return range within the 20% capped portfolio composition to the property asset class of the constrained multi-asset portfolio in Japan after the GFC (from July 2009 to December 2018).

3.5.2.3 Australia

For all REIT sub-sectors, the findings of Lin *et al*. (2019a) demonstrate that industrial (average allocation = 12.9%) and retail (6.2%) REITs predominantly configured the capped 20% allocations of the total property exposure in mixed-asset portfolios in Australia from January 2000 to August 2018. Other REIT sub-sectors (diversified, office, residential and specialty REITs) did not play any role in the constrained portfolio compositions. In the sub-period analysis, industrial REITs still dominated capped portfolio composition in the pre-GFC and post-GFC constrained mixed-asset portfolios, while the other REIT sub-sectors played only a negligible role in the constrained portfolio allocations during two timeframes. Newell *et al*. (2015) show the effectiveness of residential funds based on a hypothetical residential portfolio in an Australian context.

Importantly, Lin *et al*. (2019a) demonstrate the existence of REIT specialisation value in Australia from January 2000 to August 2018 by comparing risk-adjusted returns, portfolio diversifications and roles in multi-asset portfolios for sector-specific and diversified REITs in Australia.

3.5.2.4 Singapore

For the traditional REIT sub-sectors, Sing and Ling (2003) examine the weight portfolio allocations of diversified, office, retail and industrial HPTs in optimal downside risk mixed-asset portfolios from 1995 to 2002. The results indicate that office HPTs were the highest contributor to the optimal downside risk mixed-asset portfolio, followed by retail REITs. They also document that all HPT sub-sectors were located in the lower end of the risk-return scale, with stocks in the higher-end of the range.

For industrial REITs, Lin *et al*. (2020) observe that I&L REITs was identified as the best contributor to the constrained mixed-asset portfolio in Singapore from July 2011 to December 2018. Specifically, the average portfolio allocation of I&L REITs was 18.5% within 20% capped portfolio compositions, coexisting with both stocks and bonds across the entire risk-return band over the sample period. The added-value role of I&L REITs in the Singapore mixed-asset portfolios was reinforced by several robustness checks, including the Pacific Rim-based portfolio, downside risk portfolio and regional I&L REIT portfolio.

3.6 INTEREST RATE RISK

3.6.1 Linkage between Interest Rates and REIT Returns

Since the GFC, global markets have been confronted with high unemployment rates and slow economic growth. To stimulate domestic economic expansion, major central banks throughout the world adopted quantitative easing (QE) by injecting liquidities and lowering interest rates – to zero or even lower – in order to stimulate borrowing and spending activities (Volker, 2009; Claessens *et al*., 2010; Mishkin, 2011; Rey, 2013; Claeys and Leandro, 2016). According to Rey’s (2013) research, monetary policy is one of the most critical determinants of the global financial cycle, affecting the leverage of global banks and both credit flows and credit growth in the international financial system. In addition to the policy of QE in the USA, the Bank of the UK has cut interest rates since 2009, and the European Central Bank began its QE in 2015 in order to reduce short-term interest rates to near zero to relieve borrowing costs and accelerate market deals in domestic markets (Claeys and Leandro, 2016). Japan had already been implementing unconventional monetary policy for more than 15 years in order to invigorate the domestic economy (Volker, 2009).

The purpose of the monetary policy is not only to motivate economic expansion and enhance inflation to benefit financial stability, but also to encourage investment in risk-bearing assets. However, risk-bearing investment has become excessive and has led to marked increases in asset prices, which became disconnected from market fundamentals as one of the side effects of the QE programs (Claeys and Leandro, 2016). Given interest rates are close to or even below zero, low-interest rates and liquidity injections have dropped capitalisation yields but heightened property values in recent years, particularly in Europe and Japan where QE has been extensively employed. Numerous studies have highlighted the strong correlation between interest rates and cap rates in the international property investment space in recent years (Ambrose and Nourse, 1993; Conner and Liang, 2005; Hollies, 2007; Tsolacos *et al*., 2009; Hess and Macha, 2012; Manganelli *et al*., 2014; Fang *et al*., 2016). Hess and Macha (2012) illustrate the linkage between interest rates and property cap yields. They identify three main reasons property cap yields respond to long-term rather than short-term interest rates. Firstly, property trades are geographically dependent and illiquid compared with stocks and bonds based on daily, weekly and monthly adjustments, which could frequently react to changes in short-term interest rates. Secondly, property transactions typically take months to close deals compared with the simple trades of stocks and bonds. Lastly, as cap yields drop lesser cap yields need to be adjusted on movements in interest rate volatility.

At a single sector level, Conner and Liang (2005) examine the US property market by using three data series from the National Council of Real Estate Investment Fiduciaries (NCREIF). The results show that an increase of 100 bps on interest rates led cap rates of office property (an increase of 50 bps), retail property (51), industrial property (53) and residential property (40). They conclude that both falling property income and rising asset value cause property cap rate falls. However, they note that the trend does not apply to all property sectors. Hollies (2007) examines the linkage between office cap yields and both short- and long-term interest rates by assessing 48 office markets in the international context. The results indicate that higher short-term interest rates produced higher office cap yields across all locations in the study. Tsolacos *et al*. (2009) define retail cap yields as a function of the real rental growth and long-term interest rate in eight cities in the Asia-Pacific (Beijing, Shanghai, Hong Kong, Delhi, Mumbai, Tokyo, Singapore and Sydney) from 2001 to 2007. They find that retail cap yields were sensitive to the long-term interest rate. Specifically, a movement of 100 bps on the long-term interest rate changed retail cap yields by over 80 bps. On the other hand, retail cap yields were less sensitive to real rent growth; an increase of 100 bps on real rent growth declined retail cap yields by just five bps.

Given that historically low interest rates have led to a lower level of property market capitalisation yields in the international context, global property transaction volumes have dropped slightly since 2016 (Deloitte, 2017; JLL, 2016b; 2017; PREI, 2017b; CBRE, 2018a, 2018c). Real Capital Analytics (RCA, 2018b) explains the reasons for the slowdown of global property transactions in recent years. On the supply side, property owners are not motivated to sell their assets at a lower price level, and they bear lower costs for holding assets under low-interest rates. On the demand side, investors are not motivated to take part in the global property investment space for low property cap yields. If investors sell assets when they intend to buy other properties under a full-price environment, they could receive lesser returns from their investments. These reasons underlie the decrease in the global property transaction volumes in recent years. To compensate for lower cap yields and counter with the potential for future rising interest rates, international property investors have focused on income-producing commercial properties in the sub-market region for higher returns and stable income streams (RCA, 2018b). These property investment strategies are also reported by CBRE (2018b), with property investors willing to buy lower-yield commercial properties that offer stable incomes and returns, anticipating the future growth of these properties in order to gain higher cap rates in the future. These strategies have seen property investors increasingly attracted to international commercial properties, such as REITs. Comparable evidence is documented by Bohjalian (2018). The findings illustrate that REITs are favoured in institutional investors' mixed-asset portfolios because they offer strong and stable cash flows, the lowest correlation with stocks between 2002 and 2018 and lower taxes. In particular, the strong and stable cash flow offered by REITs can potentially offset the effects of rising interest rates. The low correlation with stocks can deliver enhanced portfolio diversification benefits for investors seeking commercial property exposure in the international context. Specifically, the results suggested that office, residential and data centre REITs in the USA, logistics, healthcare and specialty REITs in the USA, office and residential REITs in Europe and office RETs in the Asia-Pacific are attractive investment assets for property investors seeking listed property exposure internationally.

On top of practitioners' concerns over future rising interest rates, the term structure of property leases can be substantially impacted by the interest rate risk (Grenadier, 1996, 2005; Clapham and Gunnelin, 2003; Crosby *et al.*, 2003, 2006; Ambrose and Yildirim, 2008; Agarwal *et al*., 2011). This is because the lease term structure is a function of the expectations of future short-term lease rates, similar to the hypothesis in interest rate term structure models (Grenadier, 2005; Ambrose and Yildirim, 2008). Specifically, rising interest rates result in increased financing costs for property development projects, falling occupational demand, oversupply in the property submarkets, upward pressure on yields and, therefore, a decrease in property capital values (Liu and Mei, 1992; Liang *et al.*, 1995; French, 2019).

3.6.2 Interest Rate Sensitivity of Sector-specific REITs

With strong and stable income streams, REIT investments have been seen as compensating for lower cap yields and buffering against the rising interest rates in the current low-interest rate investment environment (CBRE, 2018a, c; RCA, 2018b; Bohjalian, 2018). This highlights the importance of assessing the linkage between interest rate changes and REIT returns in order to enhance institutional investors' property investment decision-making. Scholars have recently assessed the impact of interest rates on indirect property in the USA (Liu and Mei, 1992; Liang *et al*., 1995; Mueller and Pauley, 1995; Ling and Naranjo, 1997; Peterson and Hsieh, 1997; Chen and Tzang, 1988; Allen *et al*., 2000; Swanson *et al*., 2002; Ling *et al*., 2003; Bredin *et al*., 2007, 2011; Cheong *et al*., 2009; Chang *et al*., 2011), Europe (Lizieri and Satchell, 1997; Stevenson *et al*., 2007; Lee *et al*., 2014; Akimov *et al*., 2020), the Asia-Pacific (Liow *et al*., 2003; Liow and Huang, 2006) and globally (Su *et al*., 2010; Xu and Yang, 2011; Akimov *et al*., 2015; Lee *et al*., 2017).

In the USA, Ling and Naranjo (1997) consider the term structure of interest rates as one of fundamental market drivers that systematically affect both REIT and direct property returns in the USA. They explore the linkage between interest rates and both REIT and direct property returns from 1978 to 1994, using a standard multifactor asset pricing (MAP) model. Their results indicate that the term structure of interest rates had no risk premium in a fixed-efficient model, and they report time-varying interest rate sensitivity of REITs. They conclude that interest rates are a crucial risk factor for both REITs and direct property in the USA. Using a variance decomposition approach, Bredin *et al*. (2011) note that monetary policy rate surprises consistently had an influence on REIT returns in the USA from 1996 to 2005. They state that the dividend was the main reason for this influence.

Scholars have also examined the interest rate sensitivity of US REIT sub-classes using a broad range of methodologies, including a seemingly unrelated regression (SUR) framework (Allen *et al*., 2000), GARCH-M model (Devaney, 2001; Bredin *et al*., 2007), capital asset pricing model (CAPM) (Chen and Tzang, 2003), flexible least squares (FLS) (Ling *et al*., 2003) and co-integration test (Cheong *et al*., 2009). Liang *et al*. (1995) barely find evidence of long-term interest rate sensitivity in mortgage US-REITs from 1983 to 1990. Swanson *et al*. (2002) confirm that total returns of equity, mortgage and hybrid US-REITs were highly sensitive to changes in interest rate volatility from 1989 to 1993, as well as from 1994 to 1998. Chang *et al*. (2011) report that equity US-REIT returns had been responsive to either long-term interest rates or the interest rate spread from 1975 to 2008, but the effect was not persistent. Allen *et al*. (2000) highlight the importance of asset structure, financial leverage, management strategy and degree of specialisation as the main characteristics in examining the sensitivity of REITs returns to interest rates changes. They employ the SUR framework, with 26 E-REITs and 20 non-equity US-REITs over 1993–1997. The findings indicate equity REITs returns were highly sensitive to short- and long-term interest rates changes, while there was no evidence that REITs could affect their exposure to interest rates changes through asset structure, financial leverage, management strategy or degree of specialisation. Devaney (2001) uses monthly excess returns of 176 equity REITs and 27 mortgage REITs in the USA to investigate the effects of the volatility of interest rates on US-REITs from 1978 to 1998. The findings show that changes in interest rates were inversely related to returns of both equity REITs and mortgage REITs in the USA. In addition, the GARCH-M model was found to be more appropriate for mortgage REITs than equity REITs. Bredin *et al*. (2007) find similar evidence using the GARCH model to examine the effects of unanticipated changes in monetary policy in the USA on the investment performance of US equity REITs from 1996 to 2005. They find insignificant results and explain that the GARCH-M model could not interpret both unexpected and incorporated changes within the model.

Chen and Tzang (2003) employ the CAP model proposed by Merton (1980) to discuss whether equity REITs and mortgage REITs are sensitive to changes in the short- and long-term interest rates in the USA from 1973 to 1985. The results indicate that both equity

REITs and mortgage REITs were sensitive to both the short- and long-term interest rate series in the USA. Ling *et al*. (2003) test the impact of seven interest rate proxies in the USA on the investment performance of both equity REITs and mortgage REITs from 1972 to 1998 by using the FLS method. They find that mortgage REITs were vulnerable to all interest rate proxies, but equity REITs were only influenced by changes in yields on long-term US government bonds and high-yield corporate bonds. They highlight that both equity and mortgage REIT returns were highly susceptible to changes in yields on high-yield corporate bonds over the study period. He *et al*. (2013) use monthly total returns of equity and mortgage REITs in the USA and examine the linkage between interest rate proxies and REITs from 1972 to 1998. The results show that REITs were most vulnerable to movements in long-term yields and low-grade corporate bonds. Cheong *et al*. (2009) examine the interest rate sensitivity of equity and mortgage REITs and Real Estate Management Company (REMD) from 1990 to 2005, using the co-integration test proposed by Inoue (1999). They report that changes in equity returns were co-integrated with interest rate movements in the long run.

In Europe, there have been two studies examining the issue in the UK context prior to the introduction of REITs in the UK. Lizieri and Satchell (1997) explore the linkage between interest rates and listed property companies in the UK using the threshold autoregressive (TAR) model. The results indicate that listed property company returns were highly sensitive to interest rate changes from 1975 to 1995. They highlight that the effect of higher interest rates was sharper than that of lower interest rates. The strong linkage between the interest rate and listed property company returns was associated with the fact that rising interest rates can lower the market value of commercial properties by increasing the difficulty of borrowing to fund and finance properties, and can also increase cap rates. On the other hand, property investors could benefit from increased income and capital growth in commercial properties under a lower interest rate environment, in which the real value of debt on commercial properties is eroded. Adopting the same view of the traded property market as one of the industry sectors highly vulnerable to fluctuations in interest rates, Stevenson *et al*. (2007) employ a GARCH-M model to examine the short- and long-term interest rate sensitivity of listed property companies from January 1993 to June 2003, using daily total return indices. The results reveal that listed property companies were highly susceptible to movements in the long-term interest rates in the UK. Nevertheless, they note that listed property companies had a time-varying sensitivity to interest rate movements, particularly in a lower or stable interest rate environment, as noted by Chen and Tzang (1988), Kane and Unal (1988), Yourougou (1990), Liang *et al*. (1995) and He *et al*. (2003). Following the introduction of European REITs, Lee *et al*. (2014) use daily excess returns of European public properties across seven markets (the UK, the Netherlands, France, Germany, Sweden, Switzerland and Belgium) to investigate sensitivity to movements in both the short- and long-term interest rates at market and company levels from 1996 to 2013. The GARCH-M results generally show that all listed property sectors were sensitive to changes in interest rates. The firm-level results suggest that asset-structure and book-to-market of European public properties were the driving forces behind the influence of interest rate changes. They also observe that REITs were more effective for reducing risk exposure than property companies in the region.

In the Asia-Pacific, Liow *et al*. (2003) examine the sensitivity of S-REITs to unexpected long-term interest rate fluctuations from 1992 to 2001, after the Asian Financial Crisis. They collected weekly total returns of 18 REITs in Singapore using the arbitrage pricing theory (APT) framework. The results indicate that S-REITs were sensitive to movements in unanticipated long-term interest rates. Lean and Smyth (2012) examine the Malaysian REIT market from 2006 to 2009, using co-integration and Granger causality tests. In an A-REIT context, Wong and Reddy (2018) find that medium-size A-REITs were more sensitive to fluctuations in both short- and long-term interest rates. Ratcliffe and Dimowski (2007) note A-REITs were negatively related with long-term interest rates but were insignificantly related with movements in short-term interest rates. Yong and Singh (2015) report the significant and negative influence of interest rate risk upon A-REITs in the period of expanding market conditions. Reddy and Wong (2018) suggest that A-REIT investors could mitigate interest rate risk by selecting an Australian REIT with less leverage and large market capitalisation.

In the international REIT context, Liow and Huang (2006) employ a GARCH-M model to examine whether changes in interest rates affected excess monthly returns of listed property companies in Asia (Singapore, Hong Kong and Japan) and the UK from 1987 to 2003. The findings indicate that listed property company returns were sensitive to movements in both the short- and long-term interest rate series. Additionally, they observe that the disparities in both the magnitude and the direction of sensitivity affect the level and the volatility of interest rate series across the region. Therefore, they suggest that different market conditions should be considered within the portfolio construction and portfolio management in order to reduce interest rate exposures and hedge interest rate risks. Su *et al*. (2010) examine the interest rate sensitivity of REITs in Japan and the USA from 2003 to 2007. They find that REIT returns in Japan and the USA shared the same hybrid form, but these two markets featured different patterns on the interest rate sensitivity. J-REIT returns were negatively sensitive to the long-term interest rates, while the sensitivity of US-REITs was insignificant.

Similarly, Xu and Yang (2011) highlight the asymmetric impacts of the US monetary policy surprises on the international securitised property markets from 1993 to 2004. These REIT markets were the USA, Australia, Canada, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK, Hong Kong, Japan and Singapore. The results show that the international securitised property markets react positively to changes in the Federal Reserve's monetary policy on interest rates. They propose that these 18 markets responded divergently on changes in interest rates in the USA due to cross-country variation in degrees of financial integration, as noted by Bardhan *et al*. (2008). Akimov *et al*. (2015) investigate the unanticipated interest rate sensitivity of REITs in six REIT markets, namely the USA, the UK, Japan, Australia, Singapore and Hong Kong, from 1995 to 2012. The findings indicate that changes in both short- and long-term interest rate series had strong explanatory power for REIT returns across these six REIT markets over the study period. They note that the degree of the interest rate sensitivity of REITs varied across the six markets and over time. Lee *et al*. (2018) utilise daily data of property securities across 11 developed markets, – Australia, France, Germany, Hong Kong, Japan, the Netherlands, Singapore, Sweden, Switzerland, the USA and the UK – from 1990 to 2014. The Spline GARCH results indicated a strong linkage between low-frequency volatility of property securities across the 11 markets and interest rate risk proxies.

Overall, the importance of the interest rate proxy used on the results of the sensitivity is highlighted by He *et al*. (2003). Hence, recent literature, such as Stevenson *et al*. (2007)

and Lee *et al*. (2014), has employed a broad range of interest rate proxies to investigate the interest rate sensitivity of listed property stocks. In addition, varying degrees of interest rate sensitivity of REITs across different markets are reported in the international literature, such as Su *et al*. (2010), Xu and Yang (2011), Akimov *et al*. (2015) and Lee *et al*. (2018). The investment differences across different markets can be explained by cross-country variation in the countries' levels of financial integration, as noted by Bardhan *et al*. (2008). Furthermore, time-varying interest rate sensitivity results have been frequently observed (Ling and Naranjo, 1997; He *et al*., 2003; Liow and Huang, 2006; Stevenson *et al*., 2007; Akimov *et al*., 2015). These show the importance of updated evidence on the interest rate sensitivity of REITs across different markets, with the use of different interest rate proxies.

3.7.3 SUMMARY OF RESEARCH GAPS IN THE CURRENT LITERATURE

Chapter 3 has reviewed the extensive literature on various research aspects of REITs in general and REIT sub-sectors in particular. These issues include the linkage with direct property, property market fundamentals, investment performance, portfolio diversifications, roles in mixed-asset portfolios and interest rate sensitivity of REIT sub-sectors across the Asia-Pacific and US contexts. This chapter has found that the scholarly literature on these research aspects has been extremely limited for sector-specific REITs. Hence, this study intends to remedy the research gaps, which provide the structure and theoretical framework of this thesis.

As documented in Chapter 2, one of the prominent attributes of REITs is that sector-specific REITs play a prevailing role in the REIT markets across the Asia-Pacific, USA and Europe compared with diversified REITs. The effect of specialisation value can explain this market trend. Limited studies furnish evidence against the assertion of REIT specialisation value in the USA before the GFC by taking different property types of REITs as a hybrid specialised REIT portfolio. Owing to the fact that various property sectors may characterise distinct market cycles (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Chong *et al*., 2012; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a), it is vital to scrutinise risk-return differences between different property types of REITs and diversified REITs. However, no comparable study has validated the REIT specialisation value at a single REIT sub-sector level.

These findings of this study, as presented in subsequent chapters, thus contribute to the literature in a number of ways. Firstly, this is the first study to assess the added-value and strategic role of different property types of REITs in the Asia-Pacific from July 2006 to December 2018, with validation against the US-REIT market. Secondly, this study is the first to demonstrate risk-return differences between different property types of REITs and diversified REITs, by assessing risk-return attributes of sector-specific REITs and diversified REITs. The coverage of this study particularly highlights multi-dimensional investment research aspects of the investment performance, portfolio diversification benefits, roles in mixed-asset portfolios and interest rate sensitivity of different property types of REITs, benchmarked against diversified REITs. Thirdly, this study is the first to offer some international evidence for REIT specialisation value. Fourthly, previous studies did not consider REIT specialisation value in the post-GFC context; this study offers updated, empirical, international evidence of REIT specialisation value in the post-GFC context. Lastly, this study is the first to demonstrate that different property types of REITs have divergent responses to changes in interest rates, with respect to distinct market cycles for each property sector.

The next chapter will introduce the data used and the methodology employed to achieve the research objectives of this thesis. The analyses on these research issues will then be assessed and discussed in Chapter 5, 6, 7, 8 and 9.

CHAPTER 4
DATA AND METHODOLOGY

Chapter 4 provides a description of the dataset and methodologies employed in this research. The theories and methodologies introduced in this chapter are used for the analyses in the following chapters, including risk-adjusted performance, portfolio diversifications, risk-adjusted performance comparison, optimal and constrained mixed-asset portfolio and interest rate sensitivity analyses. The index construction methodology for all sector-specific REITs in the Asia-Pacific region and the USA are explored.

4.1 INTRODUCTION

The previous chapter highlighted that the research gap addressed by this thesis is the comparison different property types of REITs and diversified REITs from multi-dimensional investment aspects including risk-adjusted returns, portfolio diversification benefits, risk-adjusted performance comparisons, roles in mixed-asset portfolios in domestic, regional and international contexts, different property types of regional REIT-based portfolios and interest rate sensitivity. This chapter outlines the types of data used to bridge this research gap and their timeframes, as well as the methods used. These methodologies are (1) performance analysis (objectives 1, 2, 3 and 6); (2) portfolio analysis (objectives 1, 2, 3 and 6); (3) regional REIT-based portfolio analysis (objectives 4 and 6); and (4) interest rate sensitivity analysis (objectives 5 and 6). The sub-period analysis was employed to capture the dynamic investment performance of sector-specific REITs across various domestic jurisdictions, and to reinforce the existence of REIT specialisation value in the Asia-Pacific region. The timeframe was divided into two sub-periods: pre-GFC (July 2006–September 2007) and post-GFC (July 2009–December 2018). The performance, portfolio and regional REIT-based portfolio and interest rate sensitivity analyses were undertaken for each sub-period.

4.2 TYPES AND SOURCES OF DATA

4.2.1 Domestic Context

To assess risk-return profiles of REIT sub-sectors benchmarked against the mainstream asset classes, the data used in the analysis for domestic markets comprise monthly total returns of stocks, bonds and cash. Monthly total returns were estimated from July 2006 to December 2018 for both REIT sub-sectors and the mainstream asset classes in the USA, Japan, Australia and Singapore (since REIT sub-sector indices in Singapore can only be tracked back to July 2006). However, the current REIT sub-sector indices across Japan, Australia and Singapore from major index providers (e.g. S&P, MSCI, Thomson Reuters Eikon, NAREIT) are not available for July 2006. To offer a comprehensive understanding of REIT specialisation value in the Asia-Pacific, the custom market value-weighted free-float-adjusted YCL/UNSW monthly total return indices for sector-specific and diversified REITs were constructed across Japan, Australia and Singapore. This is despite that free-floating adjusted indices can often cause distortions if there are limited equities, and the index is overwhelmed by a single large market capitalisation company (S&P Global, 2020). However, the comparably small sample series used in this study have at least 4 REIT equities. This is due to that this study considers the survival bias issue and includes both active and delisted REIT equities for each REIT sub-sector index across three sample markets. Importantly, breaking down the REIT market into sub-sectors will definitely reduce the number in each property sector series. For the rights issue, all Thomson Reuters Datastream's equity data has been processed by capital actions (Thomson Reuters, 2020). Therefore, each equity data is adjusted for stock splits, dividends and rights issues. Since the constitutions of all REIT sub-sector indices used in this study are sourced from Thomson Reuters Datastream's REIT equities across the sample markets, returns of each REIT sub-sector indices used in this study are adjusted for rights issues in the process of index construction.

The US REIT sub-sectors were sourced from FTSE/EPRA/NAREIT REIT sub-sector monthly total returns series. Importantly, REIT sub-sectors across these four markets were categorised by the GICS. Direct property total return series were excluded in this study, since the monthly series from major index providers (e.g. NREIF, INREV, ANREV, MSCI) are not available and the coverage is over a shorter timeframe (mostly from 2009).

Importantly, this study aims to demonstrate REIT specialisation value in the Asia-Pacific region, rather than specialisation value for direct property.

Apart from monthly total return indices, the data used in the interest sensitivity analysis are on a daily basis, since daily data can provide a more intuitive relationship with the capital markets (Cotter and Stevenson, 2007; Stevenson et al., 2007). Due to the inactive S&P and FTSE/EPRA/NAREIT indices for REIT sub-sectors across these four markets, market value-weighted free-float-adjusted YCL/UNSW daily total return indices for REIT sub-sectors across the USA, Japan, Australia and Singapore were constructed. The short-term interest rates were proxied using the 3-month interest rate across these four markets, while the long-term interest rates were sourced from the yield on 10-year government bonds. Excess returns were measured as REIT sub-sector returns minus the month yield on 10-year government bonds. Although the stock indices of sample markets include REITs, the baseline results may not be strongly affected by the exclusion of REITs from the stock indices since REITs have played a comparably small role in the overall stock markets across the USA (3.1%), Japan (1.8%), Australia (7.5%) and Singapore (11.3%) over the sample period. **Table 4-1** describes the data series used in the domestic context.

Table 4-1: Data description: domestic

Markets	Assets	Data series
	REITs	
	Office	YCL/UNSW Japan office REITs TRI (JP¥)
	Retail	YCL/UNSW Japan retail REITs TRI (JP¥)
Japan	Industrial	YCL/UNSW Japan industrial REITs TRI (JP¥)
	Residential	YCL/UNSW Japan residential REITs TRI (JP¥)
	Specialty	YCL/UNSW Japan specialty REITs TRI (JP¥)
	Diversified	YCL/UNSW Japan diversified REITs TRI (JP¥)
	Stocks	DJGL Japan TRI (JP¥)
	Bonds/IR10y	JP 10-years Government Bond
	Cash/IR3m	JP 3-month interbank rate
	REITs	
	Office	YCL/UNSW Australian office REITs TRI (AU$)
	Retail	YCL/UNSW Australian retail REITs TRI (AU$)
	Industrial	YCL/UNSW Australian industrial REITs TRI (AU$)
Australia	Residential	YCL/UNSW Australian residential REITs TRI (AU$)
	Specialty	YCL/UNSW Australian specialty REITs TRI (AU$)
	Diversified	YCL/UNSW Australian diversified REITs TRI (AU$)
	Stocks	S&P/ASX 300 TRI (AU$)
	Bonds	AU Commonwealth 10-year Government Bond
	Cash	AU 3-month Interbank Rate
	IR10y	Reserve Bank of Australia 10-year Government Bond
	IR3m	Reserve Bank of Australia 3-month Bank Accepted Bill
	REITs	
	Office	YCL/UNSW Singapore office REITs TRI (S$)
	Retail	YCL/UNSW Singapore retail REITs TRI (S$)
	Industrial	YCL/UNSW Singapore industrial REITs TRI (S$)
Singapore	Residential	YCL/UNSW Singapore residential REITs TRI (S$)
	Specialty	YCL/UNSW Singapore specialty REITs TRI (S$)
	Diversified	YCL/UNSW Singapore diversified REITs TRI (S$)
	Stocks	DJGL Singapore TRI (S$)
	Bonds/IR10y	SP 10-years Government Bond
	Cash/IR3m	SP 3-month interbank rate
	REITs-M	
	Office	FTSE EPRA/NAREIT US office REITs TRI ($)
	Retail	FTSE EPRA/NAREIT US retail REITs TRI ($)
	Industrial	FTSE EPRA/NAREIT US industrial REITs TRI ($)
	Residential	FTSE EPRA/NAREIT US residential REITs TRI ($)
	Specialty	FTSE EPRA/NAREIT US specialty REITs TRI ($)
	Diversified	FTSE EPRA/NAREIT US diversified REITs TRI ($)
US	REITs-D	
	Office	YCL/UNSW US office REITs TRI ($)
	Retail	YCL/UNSW US retail REITs TRI ($)
	Industrial	YCL/UNSW US industrial REITs TRI ($)
	Residential	YCL/UNSW US residential REITs TRI ($)
	Specialty	YCL/UNSW US specialty REITs TRI ($)
	Diversified	YCL/UNSW US diversified REITs TRI ($)
	Stocks	S&P 500 composite TRI (US$)
	Bonds/IR10y	US Treasury 10-years Bond
	Cash/IR3m	US 3-month Treasury Bill Rate

Source: Thomson Reuters Datastream
Note: TRI = Total Return Index

4.2.2 Regional and Global Contexts

At the regional level, Asia-Pacific REIT sub-sectors were construed based on a market value-weighted free-float-adjusted basis. The Asia-Pacific stock markets were collected from the MSCI All Country Asia-Pacific index. At a global level, the US and European REITs were proxied from the FTSE/EPRA/NAREIT US REIT and MSCI European REITs indices, respectively. However, regional and global bonds were not included in either regional and global investment contexts, since the regional and global bond series were not accessible for this study. The global stock market data were collected from the MSCI ACWI index. In the regional REIT sub-sector portfolio analysis, the custom market value-weighted free-float-adjusted YCL/UNSW indices for REIT sub-sectors across Japan, Australia and Singapore and the USA were measured in US dollars in order to mitigate the currency risk for international property investors. **Table 4-2** portrays the regional and global data series used for the analysis.

Table 4-2: Data description: regional and global

Markets	Assets	Data series
	REITs	
	Office	YCL/UNSW Asia-Pacific office REITs TRI ($)
	Retail	YCL/UNSW Asia-Pacific retail REITs TRI ($)
Regional	Industrial	YCL/UNSW Asia-Pacific industrial REITs TRI ($)
	Residential	YCL/UNSW Asia-Pacific residential REITs TRI ($)
	Specialty	YCL/UNSW Asia-Pacific specialty REITs TRI ($)
	Diversified	YCL/UNSW Asia-Pacific diversified REITs TRI ($)
	Stocks	MSCI All Country Asia-Pacific TRI ($)
	Asia-Pacific REITs	
	Office	YCL/UNSW Asia-Pacific office REITs TRI ($)
	Retail	YCL/UNSW Asia-Pacific retail REITs TRI ($)
	Industrial	YCL/UNSW Asia-Pacific industrial REITs TRI ($)
Global	Residential	YCL/UNSW Asia-Pacific residential REITs TRI ($)
	Specialty	YCL/UNSW Asia-Pacific specialty REITs TRI ($)
	Diversified	YCL/UNSW Asia-Pacific diversified REITs TRI ($)
	US-REITs	FTSE/EPRA/NAREIT US REITs TRI ($)
	EU-REITs	MSCI European REITs TRI ($)
	Stocks	MSCI ACWI TRI ($)

Source: Thomson Reuters Datastream
Note: TRI = Total Return Index, M = Monthly Index, D = Daily Index

4.2.3 REIT Sub-sector Indices Construction

Since REITs are required to distribute net profits as dividends to shareholders, the total return index, which includes the dividend component, is an appropriate measure to assess the investment performance of REITs, and preferable to the price index, which tracks price movement. Given that some REIT sub-sectors are not sufficiently covered by existing databases, this study contributes to existing research in offering a comprehensive view of the overall state and performance of REIT sub-sectors across Japan, Australia and Singapore by creating custom YCL/UNSW indices for REIT sub-sectors at domestic and regional levels, with the consideration of survival bias. Daily total return indices of REIT sub-sectors in the USA were also constructed. These constructed REIT sub-sector indices were market value-weighted total return indices based on free-floating outstanding shares and units. Specifically, the method employs the price appreciation and dividend distribution of REIT sub-sector equities multiplied by the number of free-floating shares in a constituent. The custom REIT sub-sector total return indices were constructed using a monthly frequency to compare with the mainstream asset classes used in this research. To accurately reflect the relationship with the capital markets, the custom REIT sub-sector total return indices were created based on a daily frequency. The YCL/UNSW index was computed as follows:

$$TRI_t = \frac{\sum_{t=1}^{n} q_{i,t} \times [(p_{i,t} \times r_{i,t}) + (d_{i,t} \times r_{i,t})]}{\sum_{t=1}^{n} q_{i,t-1} \times p_{i,t-1} \times r_{i,t-1}} \times TRI_{t-1} \quad \textbf{(4.1)}$$

where,

TRI_t = the total return index at time *t*;

$q_{i,t}$ = the number of shares of index constituent *i* at time *t*;

$p_{i,t}$ = the price of a share of index constituent *i* at time *t*;

$d_{i,t}$ = the dividend paid at time *t*;

$r_{i,t}$ = the foreign exchange rate of the index quote currency.

4.3 PERFORMANCE ANALYSIS

4.3.1 Total Return Measurements

To assess performance difference between sector-specific and diversified REITs in the Asia-Pacific, monthly total returns (**Equation 4.2**) are computed based on changes in the monthly total return index of an asset from July 2006 to December 2018. The method reflects the performance movement of an asset over the measurement timeframe.

$$TR_t = \frac{(TRI_t - TRI_{t-1})}{TRI_{t-1}} \times 100\% \tag{4.2}$$

where,
TR_t = the monthly total returns percentage at time *t*; and
TRI_t = the value of the total return index at time *t*.

To reflect the asset invested over a longer-term holding period, the geometric mean calculation (**Equation 4.3**) was employed in the study. Compared with arithmetic mean measurement, it can better measure the dynamics of a stream of monthly returns over a longer period. To provide with a more realistic investment holding period, the geometric mean monthly returns are annualised as average annualised returns (**Equation 4.4**).

$$\bar{R}_G = \left[\prod_{t=1}^{n}(1 + TR_t)\right]^{1/n} - 1 \tag{4.3}$$

where,
$\bar{R}_G$ = geometric mean monthly total returns;
TR_t = the monthly total returns observed at time *t*; and
n = number of periodic returns per annum.

$$\overline{TR}_{annual} = \left(1 + \overline{TR}_{perodic}\right)^n - 1 \tag{4.4}$$

where,
$\overline{TR}_{annual}$ = annualised mean total returns;
$\overline{TR}_{perodic}$ = geometric mean monthly total returns; and
n = frequency of observations per annum.

4.3.2 Risk Measurements

There is a wide range of risk measurements, such as the standard deviation, beta, downside risk and upside volatility. Beta is a measure of the systematic risk, capturing the co-movement of an asset with the overall equity market (Robichek and Cohn, 1974). Downside risk is utilised as a superior risk measure, since it does not necessitate a normal distribution assumption and is in line with investors' risk perception (Lee *et al*., 2008a, b, c). Compared with beta and downside risk, the standard deviation is widely understood and accepted by practitioners as a preferred investment risk measure. Hence, this study employs the standard deviation of a total return index relative to the historical arithmetic mean (**Equation 4.5**) for risk measurement.

$$SD_{annual} = \left[\sqrt{\frac{\sum_{t=1}[TR_t - \overline{TR}]^2}{p-1}}\right] \times \sqrt{n} \qquad \textbf{(4.5)}$$

where,
SD_{annual} = annualised standard deviation;
TR_t = monthly total returns observed at time *t*;
$\overline{TR}$ = mean monthly total returns;
p = size of sample; and
n = frequency of observation per annum.

4.3.3 Risk-adjusted Return Measurements

The return-to-risk ratio (**Equation 4.6**) is a normalised measure of risk-adjusted returns. It refers to the historical returns achievable per unit of risk for an asset.

$$RRR = \frac{\overline{TR}_{annual}}{SD_{annual}} \qquad \textbf{(4.6)}$$

where,
$\overline{TR}_{annual}$ = average annual total returns; and
SD_{annual} = annualised standard deviation.

The Sharpe ratio (**Equation 4.7**) is another risk-adjusted return measurement of an asset. The difference between the Sharpe ratio and return-to-risk ratio (the return/risk ratio) is that the Sharpe ratio estimates the risk-adjusted performance of an asset by dividing the asset's excess returns by its standard deviation. The excess returns of an asset are computed as average annual returns minus the risk-free rate yield on 10-year government bonds. However, the Sharpe ratio estimates the risk-adjusted returns divided by the standard deviation, which computes both the upside and downside potential of returns as the risk. This implies that the standard deviation, calculated based on the assumption of the normal distribution of returns, may lead to bias when returns are abnormal.

$$Sharpe\ ratio\ =\ \frac{(\overline{TR}_a - \overline{TR}_{rfa})}{SD_a} \qquad \textbf{(4.7)}$$

where,

$\overline{TR}_a$ = average annual total returns of an asset;

$\overline{TR}_{rfa}$ = average annual total returns of a risk-free rate; and

SD_a = annualised standard deviation of an asset.

4.3.4 Risk-adjusted Performance Comparison Analysis

To shed more light on differences between each property types of REITs and diversified REITs in terms of risk-adjusted returns, the Jobson and Korkie (1981) pairwise test was used to compare each property types of REITs with diversified REITs on a risk-adjusted return basis (the Sharpe ratio). The hypothesis of the pairwise test states that there are no differences between each property type of REITs and diversified REITs. Similar methodology has been employed by Lee *et al*. (2007) and Lin *et al*. (2019) for A-REITs. The test statistics are the sample differences $(\widehat{Sh_s} - \widehat{Sh_d})$ (**Equation 4.8**). The transformed Sharpe measurement is:

$$\widehat{Sh_{\iota n}}\ =\ \frac{\sigma_d \overline{R_s} - \sigma_s \overline{R_d}}{4T} \qquad \textbf{(4.8)}$$

The Z-test of the pairwise test is calculated as follows:

$$Z_i\ =\ \frac{\widehat{Sh_{\iota n}}}{\sqrt{\theta}} \qquad \textbf{(4.9)}$$

$$\theta\ =\ \frac{1}{T}\{2\sigma_i{}^2\sigma_m{}^2 - 2\sigma_i\sigma_m\sigma_{i,m} + \frac{1}{2}\overline{R_\iota}^2\sigma_m{}^2 + \frac{1}{2}\overline{R_m}^2\sigma_i{}^2 - \frac{\overline{R_\iota R_m}}{2\sigma_i\sigma_m}\left(\sigma_{i,m}{}^2 + \sigma_i{}^2\sigma_m{}^2\right)\} \qquad \textbf{(4.10)}$$

where $\overline{R_s}$ is the mean return premium for each property type of REITs and $\overline{R_d}$ is the mean return premium for diversified REITs, as benchmark index. σ_s is the standard deviation of each property type of REIT returns and σ_d is the standard deviation of diversified REIT returns. $\sigma_{s,d}$ is the covariance of returns between each property type of REITs and diversified REITs. T is the number of observations.

4.3.5 Portfolio Diversification Efficiency Measurement

The portfolio diversification potential between two assets in this study is estimated by the correlation coefficient (**Equation 4.11**), which quantifies the linear relationship of the returns of two investment assets. Statistically, the correlation coefficient results range from −1 (linear inverse correlation) to +1 (linear adverse correlation). If a value is less than or close to zero, the results imply that there is negative or no linear correlation between the two assets. Practically, this means that the two assets could offer better portfolio diversification benefits and reduce the portfolio risk if they are included in the same portfolio. The formula of the correlation coefficient for asset *i* and *j* is:

$$r = \frac{\sum_{t=1}^{n}\left[(TR_{i,t}-\overline{TR}_i)\times(TR_{j,t}-\overline{TR}_j)\right]}{SD_{Ri}\times SD_{Rj}} \quad \textbf{(4.11)}$$

where,

r = the value of correlation coefficient between asset *i* and asset *j*;

$TR_{i,t}$ and $TR_{j,t}$ = monthly total returns of asset *i* and *j* at time *t*;

$\overline{TR}_i$ and $\overline{TR}_j$ = average monthly total returns of asset *i* and *j*; and

SD_{Ri} and SD_{Rj} = monthly standard deviation of asset *i* and *j*.

4.4 PORTFOLIO ANALYSIS

The mean-variance or Modern Portfolio Theory (MPT) was advanced by Markowitz (1952), a Nobel memorial prize winner in 1990. The model is constructed to mathematically quantify the optimum portfolio allocation of assets, in order to either maximise portfolio returns with a given level of risk or minimise risk with a given level of returns. In particular, the MPT assumes the normal distribution of asset returns based on the geometric mean and standard deviation. Optimal and constrained multi-asset portfolio models were built and conducted using Solver in the Microsoft Excel Visual Basic Applications (VBA) programming. The mean-variance optimisation is used to assess roles of REIT sub-sectors in mixed-asset portfolios across Japan, Australia, Singapore and the USA. Constrained portfolio analysis will constrain the REIT allocation at a maximum level of 20% in mixed-asset portfolios, reflecting the typical actual total property allocation in institutional investor portfolios (NAREIT, 2019). Allocations in stocks and bonds will not be constrained, reflecting the typical actual allocations to the mainstream asset classes in institutional investor portfolios.

4.4.1 Portfolio Return Measurement

The expected average annual total returns of a portfolio (**Equation 4.12**) is a weighted average total return of individual assets in the portfolio, computed as follows:

$$E(TR_{p,t}) = \sum_{i=1}^{N} W_i \times E(TR_{i,t}) \qquad \textbf{(4.12)}$$

where,

$E(TR_{p,t})$ = expected average annual total returns of multi-asset portfolio *p*;

$TR_{i,t}$ = monthly total returns of asset *i*;

W_i = weight of asset *i*; and

N = number of assets.

4.4.2 Portfolio Risk Measurement

The expected portfolio risk (**Equation 4.13**) is measured by the covariance of the returns of the assets in the multi-asset portfolio. The formula is expressed as follows:

$$SD_p = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} W_i W_j r_{i,j} SD_i SD_j} \qquad \textbf{(4.13)}$$

where,

SD_p = expected portfolio risk (standard deviation);

W_i and W_j = weight of assets *i* and *j* in the multi-asset portfolio;

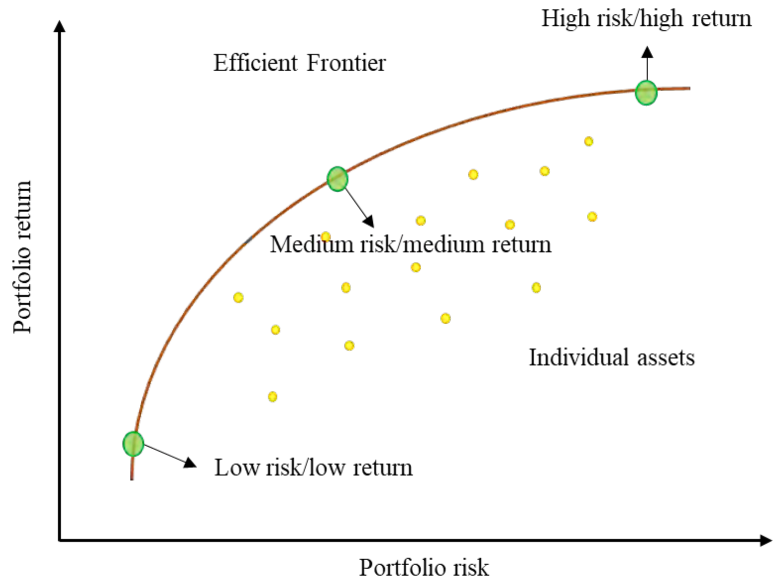
$r_{i,j}$ = correlation coefficient between assets *i* and *j*; and

SD_i and SD_j = standard deviations of assets *i* and *j*.

4.4.3 Portfolio Efficient Frontier

Since an efficient portfolio minimises the possible level of risk for a given level of expected returns, a group of potential efficient portfolios that have varying expected returns and risk levels can be graphed as the efficient frontier (**Figure 4-1**):

Figure 4-1: Theoretical mean-variance efficient frontier



4.5 INTEREST RATE SENSITIVITY REGRESSION ANALYSIS

Interest rate sensitivity regression analysis was conducted using MATLAB 2019 and EViews 10 software programs and followed standard econometric procedure. Firstly, the time series daily data for REIT sub-sectors and interest rate series across Japan, Australia, Singapore and the USA over the sample period are analysed for basic descriptive statistics, including mean, median, maximum, minimum, standard deviation, skewness, kurtosis and Jarque-Bera statistics. Secondly, the suitability of a GARCH approach for modelling REIT sub-sector excess returns is assessed using the autocorrelation function (ACF). Thirdly, the tests for serial correlation and stationarity are estimated, to perform specification and hypothesis testing on the coefficients of the models. Lastly, the GARCH-M model is tested for the results of the interest rate sensitivity of REIT sub-sectors across these four markets, with the additional diagnostics testing in order to ascertain the appropriateness of the model for the dataset.

4.5.1 Interest Rate Sensitivity Methodological Framework

This study utilises a GARCH-M model to assess the interest rate sensitivity of sector-specific REITs across Japan, Australia, Singapore and the USA, following the previous literature, such as Devaney (2001), Liow and Huang (2006), West and Worthington (2006), Stevenson *et al.* (2007), Lee *et al.* (2014; 2018), as well as the first model used by Elyasiani and Mansur (1998) in the empirical analysis of financial institutions. A GARCH-M framework differs from the standard GARCH model in that it models the mean of excess returns as a function of the conditional variance. However, a GARCH model assumes that the variance of the error term is constant. This assumption of homoskedasticity may lead to a severe problem in the analysis of financial time series, as the clustering of volatility of the sample may violate this assumption. This indicates that the GARCH-M specification allows the risk-premia to vary, which allows volatility clustering. A basic GARCH-M model (**Equation 4.14**) is presented as follows:

$$ER_t = \gamma x_t + \delta h_t + \varepsilon_t \quad \textbf{(4.14)}$$

$$h_t = \alpha_0 + \sum \alpha_i \varepsilon_{t-i}^2 + \sum \beta_j h_{t-j}^2 \quad \textbf{(4.15)}$$

$$\varepsilon_t | I_{t-1} \sim N(0, H_t) \quad \textbf{(4.16)}$$

where Equation 4.14 models the conditional mean, and Equation 4.15 models the conditional variance. The mean equation models excess returns of REIT sub-sectors (ER_t) in relation to the vector of exogenous variables (x_t) and its own conditional variance (h_t). The variance equation models the conditional variance on both lagged square errors (ε^2) and a moving average of lagged conditional variances (h_t^2).

4.5.2 Autocorrelation Function Test

To examine the suitability of a GARCH approach for modelling daily REIT sub-sector excess returns, the ACF is employed to measure the dynamics of REIT sub-sector returns and volatility, with respect to the daily data used, as documented by Cotter and Stevenson (2007) and Stevenson *et al*. (2007). The purpose of the ACF is to estimate the dependencies in the return and volatility series. The ACF is evaluated over 36 lags in this study, with squared returns used to present characteristics of the volatility series. According to Stevenson *et al*. (2007), the attributes of the volatility series for daily REIT data should be consistent with financial time series, with low persistence in returns being contrasted with relatively strong persistence in the volatility series, as reported in the finance literature. Specifically, if a strong serial correlation of volatility is found, the existence of ARCH effects will be evident, which validates the use of the GARCH approach. The formula of the ACF (**Equation 4.17**) is as follows:

$$\hat{\rho}(j) = \frac{\widehat{Cov}(ER_t, ER_{t-j})}{\widehat{Var}(ER_t)} \quad \textbf{(4.17)}$$

$$\widehat{Cov}\left(ER_t, ER_{t-j}\right) = \frac{1}{n-1}\sum_{t=j+1}^{n}(ER_t - \overline{ER})(ER_{t-j} - \overline{ER}) \quad \textbf{(4.18)}$$

$$\widehat{Var}(ER_t) = \frac{1}{n-1}\sum_{t=1}^{n}(ER_t - \overline{ER})^2 \quad \textbf{(4.19)}$$

where,

$\hat{\rho}(j)$ = the value of the j^{th} autocorrelation of REIT sub-sector *i*;

ER_t = the excess returns of REIT sub-sector *i* at time *t*;

$\overline{ER}$ = the average excess returns of REIT sub-sector *i*;

j = the lag *j*; and

n = the total number of observations.

4.5.3 Unit Root and Stationarity Tests

Since the financial time series tend to exhibit non-stationary behaviour, unit root and stationarity tests are required to measure whether these series have a variant mean, variance and autocorrelation, as documented by Davidson and MacKinnon (1993) and Hayashi (2000). In other words, if the time series data are non-stationary, the results of the regression may lead to a specious estimation since the standard errors are biased. Hence, the time series data is required to be transformed into stationary form before the analysis. In this study, the augmented Dickey-Fuller (ADF) test (**Equation 4.20**) is utilised to assess whether time series data are non-stationary using the following formula:

$H_0: Series\ is\ non-stationary$

$H_1: Series\ is\ stationary$

$$\Delta ER_t = \theta ER_{t-1} + \delta x_t' + \alpha_1 \Delta ER_{t-1} + \cdots + \alpha_p \Delta ER_{t-p} + \alpha_t \quad \textbf{(4.20)}$$

If a *p*-value is less than 5%, the null hypothesis can be rejected, indicating the time series data are non-stationary. In the analysis, a constant, constant and linear, or neither constant nor linear trend of exogenous variables needs to be decided, as well as the number of lagged difference terms of exogenous variables. Typically, the lag length chosen is sufficient to remove serial correlation in the residuals.

4.5.4 GARCH in Mean Framework

Since the interest rate is a significant variable in portfolio and capital theories for both practitioners and scholars, Merton (1980) suggests that the interpretation of the effects of changes in interest rates can offer a clear picture of shifts in the investment opportunity set. Devaney (2001), Liow and Huang (2006), West and Worthington (2006), Bredin *et al*. (2007), Stevenson *et al*. (2007) and Lee *et al*. (2014) suggest that a GARCH-M specification model is an appropriate measure to assess the interest rate sensitivity of property securities, since a GARCH-M framework incorporates a time-varying risk-premia. In this way, investors can be apprised of the volatility of an asset in relation to the risk premia investors seek. Despite the GARCH-M specification model not being directly associated with portfolio and capital theoretical frameworks. A theoretical relationship between volatility and mean returns was proposed by Engle *et al*. (1987). Neuberger (1994) also reports that the risk premia will be influenced due to the impact of volatility clustering on returns. Given this crucial feature of the GARCH-M specification, Cotter and Stevenson (2007), Stevenson *et al*. (2007) and Lee *et al*. (2014) believe that the GARCH-M model is consistent with asset pricing models, such as the capital asset pricing model (CAPM) and arbitrage pricing theory (APT).

To assess the interest rate sensitivity of REIT sub-sectors in the Asia-Pacific, with validation against the US REIT context, the basic GARCH-M model is expanded into the four-factor APT framework, comprising REIT sub-sector excess returns volatility, market excess returns, interest rates and interest rate volatility. The GARCH-M framework used in this study differs from that of Elyasiani and Mansur (1998), Devaney (2001) and Liow and Huang (2006), in which interest rate volatility was not directly incorporated into the variance equation. This study follows the approaches of Stevenson *et al*. (2007), Lee *et al*. (2014) and Lee *et al.* (2018) by including interest rate volatility in the variance equation. Furthermore, the specialisation employed in this study differs from that of Elyasiani and Mansur (1998) and Liow and Huang (2006), in which the overall stock market is included in the specialisation. Unlike dummy variables concerning the base rate set by central banks used by Devaney (2001) and Stevenson *et al*. (2007), this study does not include financial dummy variables, since the principal aim of this study is to display differential risk-return profiles of different property types of REITs and diversified REITs. This specialisation is similar to that of Lee *et al*. (2014), who demonstrate the divergent interest rate sensitivity of property securities across seven markets in Europe. The final specialisation used (**Equation 4.21 and 4.24**) is displayed as follows:

Model 1: Short-term interest rate

$$ER_{ij,t} = \theta_o + \theta_j . ER_{ij,t-1} + \rho_j . \Delta R^M_{j,t} + \mu_j . \Delta 3mIR_{j,t-1} + \delta_j . h_{j,t} + \varepsilon_{j,t} \tag{4.21}$$

$$h_{j,t} = \alpha_0 + \alpha_j . \varepsilon^2_{j,t-1} + \beta_j . h_{j,t-1} + v_{1j} . cvR^M_{j,t-1} + v_{2j} . cv3mIR_{j,t-1} \tag{4.22}$$

$$\varepsilon_{j,t} \middle| \Omega_{j,t-1} \sim N\left(0, h_{j,t}\right) \tag{4.23}$$

Model 2: Long-term interest rate

$$ER_{ij,t} = \theta_o + \theta_j . ER_{ij,t-1} + \rho_j . \Delta R^M_{j,t} + \mu_j . \Delta 10yIR_{j,t-1} + \delta_j . h_{j,t} + \varepsilon_{j,t} \tag{4.24}$$

$$h_{j,t} = \alpha_0 + \alpha_j . \varepsilon^2_{j,t-1} + \beta_j . h_{j,t-1} + v_{1j} . cvR^M_{j,t-1} + v_{2j} . cv10yIR_{j,t-1} \tag{4.25}$$

$$\varepsilon_{j,t} \middle| \Omega_{j,t-1} \sim N\left(0, h_{j,t}\right) \tag{4.26}$$

where,

ER_i = excess returns of REIT sub-sector *i*;

i = 1, 2, 3, 4, 5, 6; office, retail, industrial, residential, specialty, diversified REITs, respectively;

j = 1, 2, 3, 4; Japan, Australia, Singapore, the USA, respectively;

R^M_j = excess returns of the respective market equity index;

$3mIR_j$ and $10yIR_j$ = the respective 3-month and 10-year interest rate series;

$cvR^M_{j,t}$ = the conditional variance of the respective market equity index;

$cv3mIR_{i,t}$ and $cv10yIR_{j,t}$ = the conditional variance of the respective 3-month and 10-year interest rate series; and

$h_{j,t}$ = a conditional covariance matrix of the respective market.

Importantly, **Table 4-3** illustrates the hypotheses of the GARCH-M framework. Firstly, to investigate the linkage between excess returns and volatility of REIT sub-sectors, the null hypothesis assumes that $\theta_j = 0$ (H_1). Secondly, the existence of time-invariance for the volatility of REIT sub-sector excess returns can be tested by hypothesising $\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$ (H_2). Thirdly, to test the presence of ARCH and GARCH effects, the test can use the null hypotheses: $\theta_j = \beta_j = v_{1j} = v_{2j} = 0$ (H_3), $\beta_j = v_{1j} = v_{2j} = 0$ (H_4) and $\theta_j = v_{1j} = v_{2j} = 0$ (H_5). Also, to measure the overall stock effect on excess returns of REIT sub-sectors, the null hypothesis can be assumed, i.e. $v_{1j} = 0$ (H_6). Lastly, to confirm the interest rate effect on excess returns of REIT sub-sectors, the null hypotheses can be assumed, i.e. $v_{2j} = 0$ (H_7) and $\theta_j = v_{2j} = 0$ (H_8). Following Liow and Huang (2006), if the value of β_j is larger than that of α_j, the results imply some evidence of long memory in REIT sub-sectors.

Table 4-3: Hypotheses of GARCH-M framework

	Null hypothesis	Description
1	$\theta_j = 0$	Volatility is not a significant factor in REIT sub-sector excess returns
2	$\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$	Volatility of excess returns is time-invariant
3	$\theta_j = \beta_j = v_{1j} = v_{2j} = 0$	Return generating process follows ARCH specifications
4	$\beta_j = v_{1j} = v_{2j} = 0$	Return generating process follows ARCH-M specifications
5	$\theta_j = v_{1j} = v_{2j} = 0$	Return generating process follows GRCH specifications
6	$v_{1j} = 0$	The overall market is not a significant factor in excess returns of REIT sub-sectors
7	$v_{2j} = 0$	Volatility of interest rate is not a significant factor in REIT sub-sector excess returns
8	$\theta_j = v_{2j} = 0$	No interest rate effect on REIT sub-sector excess returns

4.6 SUMMARY OF CHAPTER

This chapter has discussed the data series and methodologies employed in this research. Chapter 5 assesses the investment performance, portfolio diversification benefits and roles in domestic mixed-asset portfolios of sector-specific REITs in the Asia-Pacific across Japan, Australia and Singapore. Chapter 6 extends these analyses to investigate Asia-Pacific-based sector-specific REITs in regional and global investment strategies. Chapter 7 utilises the analyses employed in the preceding chapters to measure the portfolio returns and risk of five different property types of regional REIT-based portfolios in the Asia-Pacific, as well as asset allocation strategies on cross-country sector-specific REITs across Japan, Australia and Singapore and the USA (as benchmark proxies). Chapter 8 specifically assesses the interest rate sensitivity of Asia-Pacific sector-specific REITs across various domestic jurisdictions. Chapter 9 validates the results of the Asia-Pacific REIT markets in the USA, in order to reinforce the findings of the thesis.

CHAPTER 5

THE SIGNIFICANCE AND PERFORMANCE OF ASIA-PACIFIC SECTOR-SPECIFIC REITs IN DOMESTIC MIXED-ASSET PORTFOLIOS

Chapter 5 aims to interpret the findings of sector-specific REITs in the domestic investment contexts in the Asia-Pacific across Japan, Australia and Singapore. The market coverage of these three markets is representative of Asia-Pacific REIT markets, contributing on average 86.6% of the total assets of Asia-Pacific REIT markets from July 2006 to December 2018. This chapter includes five sections: (1) a performance analysis, which comprises the returns, risk and risk-adjusted return analyses; (2) a correlation coefficient analysis; (3) a risk-adjusted performance comparison; (4) a mean-variance asset allocation analysis and (5) a sub-period analysis. The last section of this chapter illustrates the summary of the findings for the assessment of sector-specific REITs across these three domestic jurisdictions. The results of this chapter regarding sector-specific REITs in Japan, Australia and Singapore were externally validated by the author in three property research journal publications. In particular, a downside risk analysis was employed as an alternative risk measure in two publications. The results were consistent with the baseline results.

5.1 INTRODUCTION

The prevailing role of sector-specific REITs has been observed in the international REIT investment space in recent years. This market trend is consistent with the assertion of specialisation value in the finance literature. In the property literature, REIT specialisation value has been acknowledged by international property scholars (Capozza and Seguin; 1999; Chong *et al*., 2012; Geltner *et al*., 2014; Lin *et al*., 2019a). Some US-REIT studies have run counter to the assertion of REIT specialisation value (Benefield *et al*., 2009; Ro and Ziobrowski, 2011). Nevertheless, these studies mainly investigate US-REITs, and no international study is available in relation to REIT specialisation value. Given an adverse impact of the GFC upon REITs in the international context (Newell and Peng, 2009; Newell and Razali, 2009; Peng and Lee, 2013; Lee *et al*., 2016), it is imperative to deliver empirical international evidence of REIT specialisation value after the GFC. Unlike previous studies – which, by treating various property types of REITs as a hybrid specialised REIT portfolio, ignore the fact that distinct property sectors may characterise various market cycles (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Chong *et al*., 2012; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a) – this study is the first to compare different property types of REITs with diversified REITs, and have comprehensive insights for property investors seeking listed property exposure in the Asia-Pacific region.

Therefore, it is crucial that international REIT investors, market participants and scholars are informed of the following issues. Firstly, do sector-specific REITs outperform diversified REITs in the Asia-Pacific (RQ1)? Secondly, what roles do Asia-Pacific sector-specific REITs play in domestic multi-asset portfolios compared with diversified REITs, stocks and bonds (RQ2)? This chapter will address these key investment issues to provide a fuller understanding of REIT specialisation value in the Asia-Pacific and inform local and international investors seeking listed property exposure in the Asia-Pacific REIT of the strategic listed property investment implications for Asia-Pacific sector-specific REITs. The main thrust of this chapter is to highlight risk-adjusted returns, portfolio diversification benefits, risk-adjusted performance comparisons and roles in domestic mixed-asset portfolios of sector-specific REITs across Japan, Australia and Singapore. To accentuate the dynamic performance of sector-specific REITs across these three domestic jurisdictions from July 2006 to December 2018, comprehensive performance analyses were undertaken by comparing sector-specific REITs (office, retail, industrial, residential and specialty REITs) with diversified REITs and the mainstream asset classes (stocks and bonds). All datasets were measured in local currency in order to avoid currency exchange fluctuations and to maintain research consistency.

These analyses are undertaken based on market value-weighted free-float-adjusted REIT sub-sector total return indices across Japan, Australia and Singapore constructed for this study. The risk-adjusted performance (as measured by the Sharpe ratio) for local sector-specific REITs, diversified REITs, stocks and bonds is assessed. The statistics on monthly returns and standard deviation are annualised to represent average annualised returns and risk. The portfolio diversifications between one asset class and the others are assessed employing a correlation coefficient analysis. The optimal portfolio analysis is employed to assess the roles of sector-specific REITs in domestic mixed-asset portfolios. Following

Lin et al. (2019a, b, 2020) and Marzuki and Newell (2019), constrained portfolio analysis is utilised to reflect the practical total property allocation in institutional investor portfolio holdings. In doing so, the portfolio optimisation process used in this research assumes a maximum level of 20% for REIT allocation in mixed-asset portfolios. Asset allocation diagrams provide the empirical analysis regarding the added-value and strategic role of sector-specific REITs in domestic mixed-asset portfolios in Japan, Australia and Singapore. The sub-period analysis is employed to capture the dynamics of the investment performance of sector-specific REITs across various domestic jurisdictions, and to reinforce the existence of REIT specialisation value in the Asia-Pacific region. The timeframe is divided into two sub-periods: pre-GFC and post-GFC. The risk-adjusted returns, correlation, efficient frontiers and asset allocation diagrams are conducted for each sub-period.

This chapter is structured as follows. Section 5.2 offers the performance analysis of Japan sector-specific REITs. Section 5.3 provides the performance analysis of Australian sector-specific REITs. Section 5.4 illustrates the performance analysis of Singapore sector-specific REITs. Lastly, section 5.5 summarises the findings and investment implications of this chapter.

5.2 PERFORMANCE OF JAPAN SECTOR-SPECIFIC REITs

5.2.1 Risk-adjusted Performance Analysis

Table 5-1 lists annual returns, annual risk and risk-adjusted returns for sector-specific and diversified J-REITs, as well as the mainstream asset classes (stocks and bonds) in Japan from July 2006 to December 2018. Industrial J-REITs (8.45% p.a.) posted the highest total returns in Japan over the last 12 years, followed by residential (6.45% p.a.), office (5.64% p.a.), retail (4.91% p.a.) and specialty J-REITs (3.82% p.a.). Most sector-specific J-REITs outperformed diversified J-REITs (5.31% p.a.), except for retail and specialty J-REITs. Meanwhile, sector-specific and diversified J-REITs outperformed stocks (1.40% p.a.) and bonds (0.83% p.a.). The annual risk levels for specialty (29.83%), residential (22.55%), industrial (22.35%), retail (21.57%) and office J-REITs (20.88%) were comparatively higher than those for diversified J-REITs (20.47%), stocks (18.13%) and bonds (2.06%). On a risk-adjusted performance basis (via the Shape ratio), industrial

(0.36), residential (0.27) and office J-REITs (0.25) were superior to diversified J-REITs (0.24). In contrast, retail (0.21) and specialty J-REITs (0.12) struggled against diversified J-REITs. Compared with stocks (0.06) and bonds (0.23), sector-specific and diversified J-REITs offered superior risk-adjusted returns to the mainstream asset classes in Japan, except for specialty J-REITs. The analysis indicates the superior risk-adjusted returns of sector-specific J-REITs compared to diversified J-REITs, stocks and bonds in Japan from July 2006 to December 2018.

Table 5-1: Sector-specific J-REIT performance Analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
REITs				
Office	5.64	20.88	0.25	3
Retail	4.91	21.57	0.21	6
Industrial	8.45	22.35	0.36	1
Residential	6.45	22.55	0.27	2
Specialty	3.82	29.83	0.12	7
Diversified	5.31	20.47	0.24	4
Stocks	1.40	18.13	0.06	8
Bonds	0.83	2.06	0.23	5

Note: *Local currency

5.2.2 Diversification Benefit Analysis

Table 5-2 shows the inter-asset correlation matrix for sector-specific J-REITs, diversified J-REITs, stocks and bonds in Japan from July 2006 to December 2018. Monthly total returns of sector-specific (average $r = 0.51$) and diversified J-REITs ($r = 0.63$) exhibited significant and positive correlations with stocks. Different property types of J-REITs offered higher diversification benefits with stocks than did diversified J-REITs over the sample period, namely industrial ($r = 0.40$), retail ($r = 0.51$), specialty ($r = 0.53$), office ($r = 0.54$) and residential J-REITs ($r = 0.59$). Sector-specific (average $r = -0.06$) and diversified J-REITs ($r = -0.07$) were negatively correlated with bonds over the study period. Specifically, residential ($r = -0.08$) and specialty J-REITs ($r = -0.08$) delivered more substantial diversification benefits with bonds than did diversified J-REITs. However, office ($r = -0.06$), retail ($r = -0.06$) and industrial J-REITs ($r = -0.04$) were slightly lesser than diversified J-REITs.

In terms of an inter-property investment strategy, diversification within each property type of and diversified J-REITs (average $r = 0.79$) was not desirable. Diversification within various property types of J-REITs (average $r = 0.65$) was more attractive for investors than diversification within each property type of J-REITs and diversified J-REITs. This can be attributed to that diversified REITs comprise a property portfolio with multiple property sectors. The results suggest that sector-specific J-REITs offered a greater portfolio diversification advantage over both stocks and bonds than did diversified J-REITs. The analysis highlights that a sectoral J-REIT investment strategy could provide greater diversification benefits for property investors compared with an inter-J-REIT investment strategy.

Table 5-2: Sector-specific J-REIT correlations analysis: July 2006–December 2018

	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.14	1.00						
Diversified	0.63*	-0.07	1.00					
Office	0.54*	-0.06	0.87*	1.00				
Retail	0.51*	-0.06	0.83*	0.81*	1.00			
Industrial	0.40*	-0.04	0.69*	0.63*	0.72*	1.00		
Residential	0.59*	-0.08	0.85*	0.68*	0.72*	0.53*	1.00	
Specialty	0.53*	-0.08	0.70*	0.55*	0.60*	0.44*	0.80*	1.00

Note: *Significant correlation ($p<5\%$)

5.2.3 Risk-adjusted Performance Comparison Analysis

Table 5-3 depicts the risk-adjusted return comparison results for sector-specific and diversified J-REITs from July 2006 to December 2018. Different property types of J-REITs are statistically significant at least at the 1% significance level over the entire study timeframe. The results imply that sector-specific J-REITs were significantly different from diversified J-REITs in the Sharpe ratio.

Industrial (Z value = 56.81), residential (14.34) and office J-REITs (7.45) provided superior risk-adjusted returns to diversified J-REITs, since the Z-test statistics of these three sub-sectors are positively and statistically significant at the 1% level. In contrast, specialty (−72.54) and retail J-REITs (−16.65) offered lower risk-adjusted returns than diversified J-REITs. It was evident by the Z-test statistics that these two sub-sectors were negatively and statistically significant at the 1% level.

In sum, this suggests that sector-specific J-REITs were a significantly distinct investment asset from diversified J-REITs on a risk-adjusted return basis. Notably, the analysis validates the assertion of REIT specialisation value existing in Japan for property investors seeking listed property exposure in Japan over the full study period.

Table 5-3: Risk-adjusted performance comparison between sector-specific and diversified J-REITs: July 2006–December 2018

Portfolio	Office and Diversified	Retail and Diversified
Z-test	7.45***	-16.65***
Portfolio	Industrial and Diversified	Residential and Diversified
Z-test	56.81***	14.34***
Portfolio	Specialty and Diversified	
Z-test	-72.54***	

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

5.2.4 Mixed-asset Portfolio Analysis

Figure 5-1 depicts the efficient frontiers for various asset-mix combinations in Japan from July 2006 to December 2018, with the main focus on sector-specific J-REITs. The inclusion of industrial J-REITs in a portfolio containing financial assets (stocks and bonds) increased the upward trend of the efficient frontier curve compared to that for diversified J-REITs and the baseline financial assets-only portfolio. Industrial J-REITs was followed by residential and office J-REITs. Conversely, the respective efficient frontiers with the addition of retail and specialty J-REITs were lower than for diversified J-REITs, but were higher than the efficient frontiers of the financial assets-only portfolio.

Table 5-4 and **Figure 5-2** show the mean-variance optimisation of sector-specific J-REITs in a Japan domestic multi-asset portfolio, as well as an asset composition diagram for the risk-return spectrum. The optimal portfolio returns were between 0.86% p.a. and 8.45% p.a., while the portfolio standard deviations were between 2.00% and 22.35%. As the risk level increased, the portfolio allocations for industrial (an average allocation = 45.8%) and residential J-REITs (12.1%) enlarged their portfolio compositions, complementing bonds (41.8%) and stocks (0.2%) in the lower end of the risk-return range. Industrial J-REITs reached a maximum level at 100% in the highest end of the risk-return scale. However, there was no role for diversified J-REITs in the optimal portfolio allocations.

Figure 5-1: Sector-specific J-REIT efficient frontiers: July 2006–December 2018

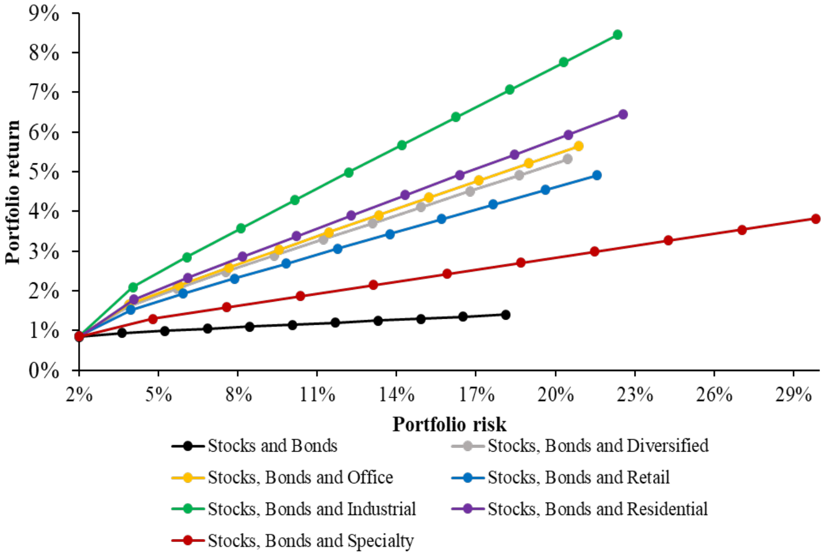
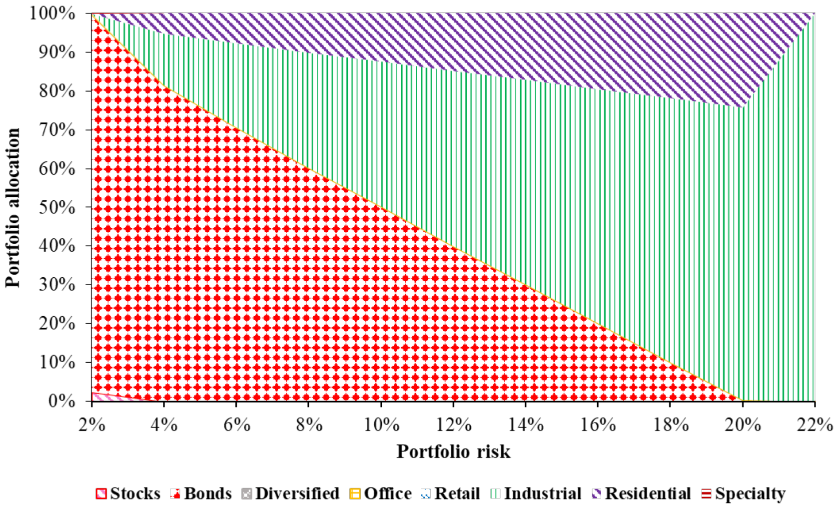


Table 5-4: Sector-specific J-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
2.5%	97.1%	0.0%	0.0%	0.3%	0.1%	0.0%	0.1%	0.86%	2.00%
0.0%	81.4%	0.0%	0.0%	0.0%	13.4%	5.2%	0.0%	2.14%	4.04%
0.0%	70.6%	0.0%	0.0%	0.0%	21.7%	7.7%	0.0%	2.92%	6.07%
0.0%	60.2%	0.0%	0.0%	0.0%	29.6%	10.1%	0.0%	3.65%	8.11%
0.0%	50.1%	0.0%	0.0%	0.0%	37.4%	12.5%	0.0%	4.38%	10.14%
0.0%	40.1%	0.0%	0.0%	0.0%	45.1%	14.8%	0.0%	5.10%	12.18%
0.0%	30.1%	0.0%	0.0%	0.0%	52.7%	17.2%	0.0%	5.81%	14.21%
0.0%	20.1%	0.0%	0.0%	0.0%	60.3%	19.5%	0.0%	6.52%	16.25%
0.0%	10.2%	0.0%	0.0%	0.0%	68.0%	21.8%	0.0%	7.23%	18.28%
0.0%	0.3%	0.0%	0.0%	0.0%	75.6%	24.2%	0.0%	7.94%	20.32%
0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	8.45%	22.35%

Figure 5-2: Sector-specific J-REIT asset allocation diagram: July 2006–December 2018



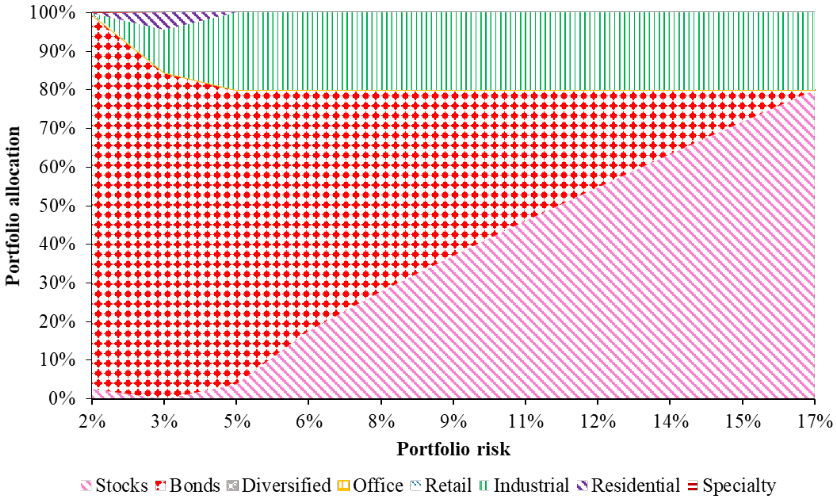
Despite the fact that the previous unconstrained mean-variance optimisation highlighted the more significant role of sector-specific J-REITs in the Japan domestic mixed-asset portfolio in comparison with diversified J-REITs, this gave over-generous portfolio allocations to sector-specific J-REITs, which were higher than the actual portfolio allocation for the property asset classes in institutional investor portfolios. Therefore, the constrained mixed-asset portfolio was conducted by applying a 20% cap on the property asset classes.

The results of the constrained mixed-asset portfolio are reported in **Table 5-5** and **Figure 5-3**. The principal role of industrial J-REITs (17.4%) is shown within the upper-bound at 20% of the total property allocations, while residential J-REITs (0.4%) had a minor role at the start of the risk-return band. Likewise, diversified J-REITs did not play any role in the constrained mixed-asset portfolio. Due to the constrained allocations for the property asset classes, stocks (36.8%) and bonds (45.4%) had more active roles in shaping the constrained mixed-asset portfolio. The imposition of the cap on sector-specific J-REITs resulted in significant reductions in the overall portfolio expected returns and risk. The analysis offers robust empirical evidence of sector-specific J-REITs being a more significant portfolio component, delivering higher portfolio returns in mixed-asset portfolios compared with their diversified counterparts over the full-time study period. This supports the assertion of REIT specialisation value in Japan from July 2006 to December 2018.

Table 5-5: Constrained sector-specific J-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
2.5%	97.1%	0.0%	0.0%	0.3%	0.1%	0.0%	0.1%	0.86%	2.00%
0.0%	84.6%	0.0%	0.0%	0.0%	11.0%	4.4%	0.0%	1.91%	3.48%
3.8%	76.2%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.37%	4.96%
17.5%	62.5%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.45%	6.44%
27.8%	52.2%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.51%	7.92%
37.2%	42.8%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.56%	9.40%
46.1%	33.9%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.61%	10.88%
54.8%	25.2%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.66%	12.36%
63.3%	16.7%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.71%	13.84%
71.7%	8.3%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.76%	15.32%
80.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	0.0%	2.81%	16.80%

Figure 5-3: Constrained sector-specific J-REIT asset allocation diagram: July 2006–December 2018



5.2.5 Sub-period Analysis

Table 5-6 lists risk-adjusted returns for sector-specific J-REITs, diversified J-REITs and the mainstream asset classes over two sub-periods. The comparisons between sector-specific and diversified J-REITs had different patterns over two sub-periods. Before the GFC, office J-REITs (1.52) were the only sector-specific J-REITs outpacing diversified J-REITs (0.83) on a risk-adjusted return basis, while the other sector-specific J-REITs were inferior to diversified J-REITs because of their lesser average annual returns. After the GFC, specialty (0.90), residential (0.87) and industrial J-REITs (0.78) provided higher risk-adjusted returns than diversified J-REITs (0.65), while retail (0.59) and office J-REITs (0.54) were slightly inferior to diversified J-REITs. Both sector-specific and diversified J-REITs underperformed bonds (3.51) on a risk-adjusted return basis before the GFC, while they were superior to bonds (0.22) after the GFC. Compared with stocks, both sector-specific and diversified J-REITs outperformed stocks over two sub-periods. This is because stocks featured comparable lower annual returns and relatively higher volatility compared with both sector-specific and diversified J-REITs.

Table 5-6: Sector-specific J-REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Office	37.64	24.41	1.52	2
Retail	14.55	23.51	0.59	4
Industrial	6.90	33.87	0.19	8
Residential	9.84	18.01	0.51	5
Specialty	9.82	22.13	0.42	6
Diversified	20.82	24.39	0.83	3
Stocks	4.77	10.29	0.40	7
Bonds	1.74	0.32	3.51	1
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Office	10.06	18.24	0.54	6
Retail	10.93	18.09	0.59	5
Industrial	14.40	18.19	0.78	3
Residential	14.14	15.96	0.87	2
Specialty	17.01	18.60	0.90	1
Diversified	11.35	17.02	0.65	4
Stocks	6.81	16.94	0.39	7
Bonds	0.59	1.62	0.22	8

Note: *Local currency

Table 5-7 presents the inter-asset correlation for sector-specific J-REITs, diversified J-REITs and the mainstream asset classes over two sub-periods. During two sub-periods, most sector-specific J-REITs (pre-GFC average $r = 0.50$; post-GFC average $r = 0.45$) were witnessed as greater portfolio diversifiers with stocks compared with diversified J-REITs ($r = 0.58$; $r = 0.55$), except for specialty J-REITs ($r = 0.73$) before the GFC. In terms of portfolio diversification benefits with bonds, most sector-specific J-REITs (average $r = -0.50$) were lesser than diversified J-REITs ($r = -0.42$) before the GFC, except for specialty ($r = -0.40$) and residential J-REITs ($r = -0.36$). After the GFC, office J-REITs was ($r = -0.01$) the only sector-specific J-REITs being superior to diversified J-REITs ($r = 0.03$), while the other property types of J-REITs (average $r = 0.09$) underperformed diversified J-REITs. Interestingly, diversification within each property type of J-REITs and diversified J-REITs (average r = 0.78) before the GFC was stronger than that in the post-GFC context (average $r = 0.82$). In contrast, diversification within various property types of J-REITs (average r = 0.68) during the post-GFC period was more attractive for investors than that (average $r = 0.74$) before the GFC. In short, despite the fact that sector-specific J-REITs offered a lesser portfolio diversification advantage over stocks and bonds than did diversified J-REITs over the two sub-periods, a sectoral J-REIT investment strategy could provide greater diversification benefits for Japan listed property investors compared with an inter-J-REIT investment strategy. The effect of a sectoral J-REIT investment strategy was more substantial in the post-GFC context for investors seeking portfolio diversifying in Japan.

Table 5-7: Sector-specific J-REIT sub-period correlations analysis

Panel A: Pre-GFC: July 2006–September 2007								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.25	1.00						
Diversified	0.58*	-0.42	1.00					
Office	0.41*	-0.57	0.75*	1.00				
Retail	0.42*	-0.65	0.78*	0.93*	1.00			
Industrial	0.37*	-0.51	0.54*	0.65*	0.72*	1.00		
Residential	0.56*	-0.36	0.90*	0.78*	0.77*	0.66*	1.00	
Specialty	0.73*	-0.40	0.93*	0.74*	0.69*	0.57*	0.87*	1.00
Panel B: Post-GFC: July 2009–December 2018								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.07	1.00						
Diversified	0.55*	0.03*	1.00					
Office	0.45*	-0.01	0.87*	1.00				
Retail	0.48*	0.07	0.87*	0.81*	1.00			
Industrial	0.43*	0.12	0.78*	0.68*	0.74*	1.00		
Residential	0.46*	0.06*	0.88*	0.72*	0.80*	0.66*	1.00	
Specialty	0.45*	0.09	0.69*	0.57*	0.64*	0.56*	0.65*	1.00

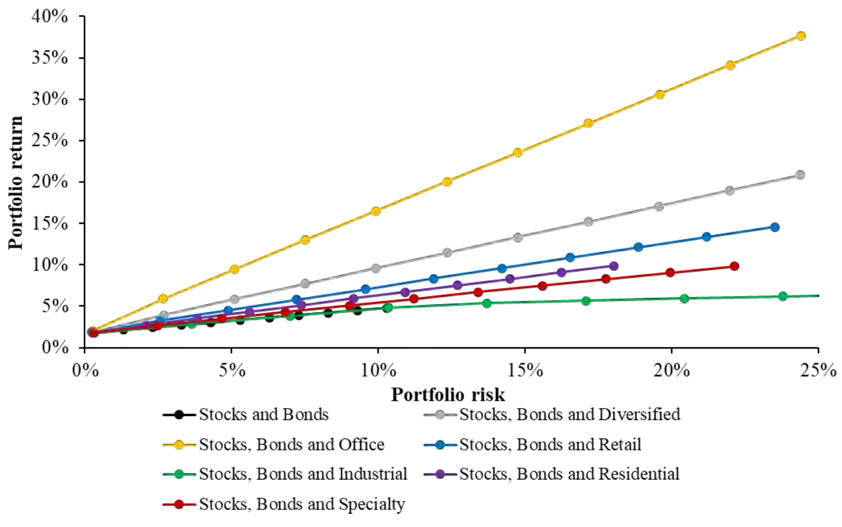
Note: *Significant correlation (p<5%)

The sub-period asset allocations and efficient frontiers for sector-specific J-REITs over the pre-GFC and post-GFC periods are displayed in **Figure 5-4** and **Figure 5-5**, respectively. Before the GFC, office J-REITs (average allocation = 15.5%) played a principal role within the scope of 20% capped total property exposure in the mixed-asset portfolio, since it registered the highest average annualised returns and relatively lower annual risk in the Japan investment context. There was no role for diversified J-REITs across the broad risk-return band. After the GFC, residential (10.3%) and industrial J-REITs (7.6%) featured prominently across the whole risk-return range within the scope of the 20% capped total property allocation. Due to the constrained allocations for the property asset classes, stocks (38.4%) and bonds (43.7%) had a greater role in shaping the constrained mixed-asset portfolio. Diversified J-REITs did not play any role across the whole risk-return scale due to their comparatively lower average annualised returns and higher volatility in the Japan investment frame. In brief, the sub-period results imply that different property types of J-REITs had stronger risk-adjusted performance and portfolio diversification benefits than diversified J-REITs over the two sub-periods. In contrast, diversified J-REITs failed to enhance portfolio performance.

5.2.6 Summary of Findings

The empirical results for different property types of J-REITs are summarised in **Table 5-8**. As seen in Panel A, risk-adjusted returns offered by sector-specific J-REITs was superior in comparison with diversified J-REITs from July 2006 to December 2018, as well as two sub-periods. Additionally, sector-specific J-REITs generally delivered stronger diversification benefits with both stocks and bonds than did diversified J-REITs, as seen in Panel B. Importantly, sector-specific J-REITs differed from diversified J-REITs on a risk-adjusted return basis, as seen in Panel C. Moving to the mixed-asset portfolio analysis (Panel D), sector-specific J-REITs were predominant across the broad risk-return range, co-existing with both stocks and bonds in mixed-asset portfolios over the entire study period, as well as two sub-periods. In contrast, diversified J-REITs did not play any role in the risk-return scale over the full sample period and two sub-periods.

Figure 5-4: Sector-specific J-REIT constrained asset allocation diagram and efficient frontiers: pre-GFC: July 2006–September 2007



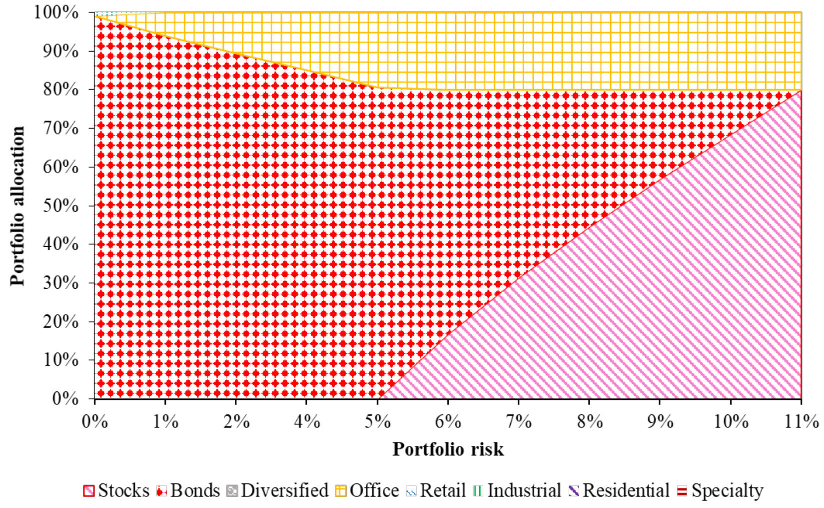
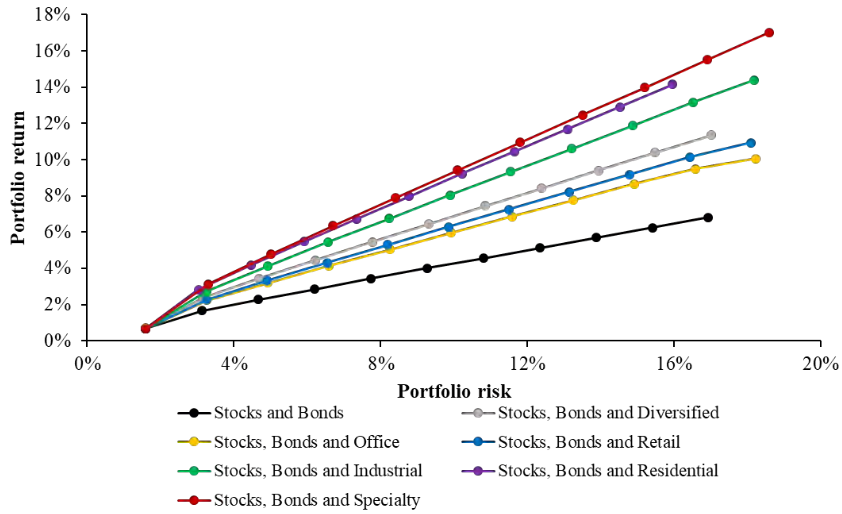


Figure 5-5: Sector-specific J-REIT constrained asset allocation diagram and efficient frontiers: post-GFC: July 2009–December 2018



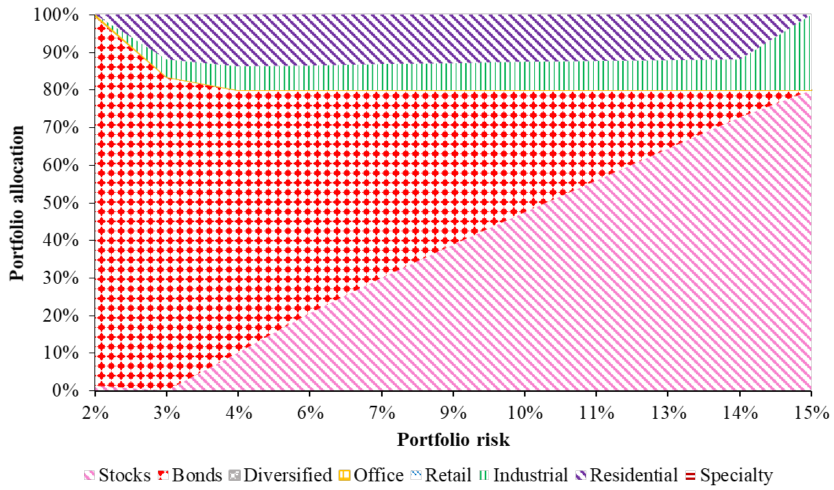


Table 5-8: Sector-specific J-REIT performance summary

Panel A: Return, risk and risk-adjusted return performance

Whole period	Asset	Return	Risk	Risk-adjusted return
1 versus	2	✔	✕	✔
	3	✔	✕	✕
	4	✔	✕	✔
Pre-GFC				
1 versus	2	✔	✔	✔
	3	✔	✕	✔
	4	✔	✕	✕
Post-GFC				
1 versus	2	✔	✔	✔
	3	✔	✔	✔
	4	✔	✕	✔

Panel B: Portfolio diversification benefits

Whole period	**1-3**	**1-4**	2-3	2-4	**1-2**
Average r =	**0.51**	**−0.06**	0.63	−0.07	**0.79**
Pre-GFC					
Average r =	**0.50**	**−0.50**	0.58	−0.42	**0.78**
Post-GFC					
Average r =	**0.45**	**0.07**	0.55	0.03	**0.82**

Panel C: Risk-adjusted performance comparison

Whole period	Office	Retail	Industrial	Residential	Specialty
Significant different from Diversified	✔	✔	✔	✔	✔

Panel D: Asset allocation

Whole period	**1**	2	3	4
Average allocation	**57.9%**	0.0%	0.2%	41.8%
Pre-GFC				
Average allocation	**15.5%**	0.0%	27.1%	57.3%
Post-GFC				
Average allocation	**60.6%**	0.0%	0.1%	39.2%

Note: 1 = sector-specific REITs, 2 = diversified REITs, 3 = stocks, 4 = bonds

5.3 PERFORMANCE OF AUSTRALIAN SECTOR-SPECIFIC REITs

5.3.1 Risk-adjusted Performance Analysis

Table 5-9 compares risk-adjusted returns of different property types of A-REITs with diversified A-REITs and Australian mainstream asset classes (stocks and bonds) from July 2006 to December 2018. Office A-REITs (5.87% p.a.) posted the highest average annual returns of all assets in the Australian investment context over the study period, followed by specialty (5.85% p.a.), retail (4.26% p.a.), industrial (3.95% p.a.) and residential A-REITs (3.38% p.a.). Importantly, different property types of A-REITs posted markedly stronger average annual returns than diversified A-REITs (1.97% p.a.). Among different property types of A-REITs, office and specialty A-REITs were the only two REIT sub-sectors posting higher average annual returns than stocks (5.48% p.a.). Office, specialty and retail A-REITs were the only three REIT sub-sectors delivering higher average annual returns than bonds (4.06% p.a.) over the whole study period. The annual risk levels for most sector-specific A-REITs (average annual risk = 19.72%) was lower than for diversified A-REITs (21.51%) – by sub-sector, retail (10.02%), specialty (17.59%), office (18.27%) and industrial A-REITs (20.09%). The only exception was residential A-REITs (32.61%). Both sector-specific and diversified A-REITs delivered higher annual risk than stocks (13.44%) and bonds (4.68%) over the full sample period.

In terms of risk-adjusted returns (via the Sharpe ratio), different property types of A-REITs surpassed diversified A-REITs (−0.09), as diversified A-REITs was the lowest risk-return performer in the Australian investment frame over the full study period. By sub-sector, these included office (0.11), specialty (0.11), retail (0.04), industrial (0.01) and specialty A-REITs (−0.01). Compared with the mainstream asset classes, all property types of A-REITs and diversified A-REITs were topped by stocks. Nonetheless, office, specialty and retail A-REITs were superior to bonds (0.04), while industrial, residential and diversified A-REITs slightly underperformed bonds. The analysis suggests superior risk-adjusted returns for sector-specific A-REITs over diversified A-REITs from July 2006 to December 2018.

Table 5-9: Sector-specific A-REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
REITs				
Office	5.87	18.27	0.11	3
Retail	4.26	10.02	0.04	4
Industrial	3.95	20.09	0.01	6
Residential	3.38	32.61	−0.01	7
Specialty	5.85	17.59	0.11	2
Diversified	1.97	21.51	−0.09	8
Stocks	5.48	13.44	0.12	1
Bonds	4.06	4.68	0.04	5

Note: *Local currency

5.3.2 Diversification Benefit Analysis

Table 5-10 shows the inter-asset correlation matrix for sector-specific A-REITs, diversified A-REITs, Australian stocks and bonds from July 2006 to December 2018. Monthly total returns for different property types of A-REITs exhibited significant and positive correlations with stocks. Compared with diversified A-REITs, different property types of A-REITs delivered stronger diversification benefits (average $r = 0.60$) over stocks than those contributed by diversified A-REITs ($r = 0.66$), namely retail ($r = 0.54$), residential ($r = 0.56$), specialty ($r = 0.59$), industrial ($r = 0.66$) and office A-REITs ($r = 0.66$). Specialty ($r = -0.21$) and industrial A-REITs ($r = -0.15$) were found to provide a greater diversification advantage over bonds than did diversified A-REITs ($r = -0.13$). The other sector-specific A-REITs, such as residential ($r = -0.10$), office ($r = -0.08$) and retail A-REITs ($r = -0.08$), were inferior to diversified A-REITs in terms of portfolio diversification benefits with bonds.

In terms of an inter-property investment strategy, diversification within each property type of A-REITs and diversified A-REITs (average $r = 0.69$) was not attractive. In contrast, diversification within various property types of A-REITs (average $r = 0.57$) was attractive for investors. This can be attributed to that a diversified REIT portfolio comprises multiple property sectors. The results imply that sector-specific A-REITs delivered higher portfolio diversification benefits than diversified A-REITs. This also indicates that a sectoral A-REIT investment strategy could provide greater diversification benefits for property investors seeking portfolio diversification benefits in Australia compared with an inter-A-REIT investment strategy.

Table 5-10: Sector-specific A-REIT correlations analysis: July 2006–December 2018

	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.05	1.00						
Diversified	0.66*	-0.13	1.00					
Office	0.66*	-0.08	0.79*	1.00				
Retail	0.54*	-0.08	0.66*	0.60*	1.00			
Industrial	0.66*	-0.15	0.83*	0.76*	0.60*	1.00		
Residential	0.56*	-0.10	0.61*	0.51*	0.36*	0.62*	1.00	
Specialty	0.59*	-0.21	0.56*	0.62*	0.41*	0.63*	0.56*	1.00

Note: *Significant correlation (p<5%)

5.3.3 Risk-adjusted Performance Comparison Analysis

Table 5-11 lists the risk-adjusted return comparison results for different property types of and diversified A-REITs from July 2006 to December 2018. Different property types of A-REITs are positively and statistically significant at the 1% level over the full sample timeframe. The results imply that each property type of A-REITs was significantly different from diversified A-REITs in the Sharpe ratio.

Specifically, office (Z value = 135.22), specialty (126.88), retail (83.46), industrial (61.88) and residential A-REITs (48.54) overtook diversified A-REITs in terms of risk-adjusted returns. This can be clarified by the Z-test statistics of these five sector-specific REITs being positive and statistically significant at the 1% level.

In brief, the results suggest that different property types of A-REITs were a significantly distinct investment asset from diversified A-REITs on a risk-adjusted return basis. Importantly, the analysis validates the notion of REIT specialisation value existing in Australia for property investors seeking listed property exposure in Australia over the full study timeframe.

Table 5-11: Risk-adjusted performance comparison between sector-specific and diversified A-REITs: July 2006–December 2018

Portfolio	Office and Diversified	Retail and Diversified
Z-test	135.32***	83.46***
Portfolio	Industrial and Diversified	Residential and Diversified
Z-test	61.88***	48.54***
Portfolio	Specialty and Diversified	
Z-test	126.88***	

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

5.3.4 Mixed-asset Portfolio Analysis

Figure 5-6 depicts various efficient frontiers for the benchmark financial assets-only portfolio and for the portfolio including sector-specific and diversified A-REITs from July 2006 to December 2018. The inclusion of each property type of A-REIT in a portfolio containing financial assets (stocks and bonds) significantly boosted the efficient frontier curve compared with the impact of including diversified A-REITs and with the baseline financial assets-only portfolio across the broad risk-return scale.

The mean-variance optimisation and asset composition diagram of different property types of A-REITs in an Australian mixed-asset portfolio over the whole study period are reported in **Table 5-12** and **Figure 5-7**. The portfolio allocations in sector-specific A-REITs (average allocation = 40.2%) were across the entire risk-return range, exceeding portfolio compositions for stocks (32.9%) and bonds (27.0%) as the risk increased, particularly in the higher end of the risk-return scale. Specifically, office A-REITs (38.3%) were present across the broad risk-return band, while retail (1.3%) and specialty A-REITs (0.6%) featured at the start of the risk-return scale. Diversified A-REITs did not play any role in the full mixed-asset portfolio composition, due to having the lowest average annual returns and the highest risk level in the Australian investment frame.

Figure 5-6: Sector-specific A-REIT efficient frontiers: July 2006–December 2018

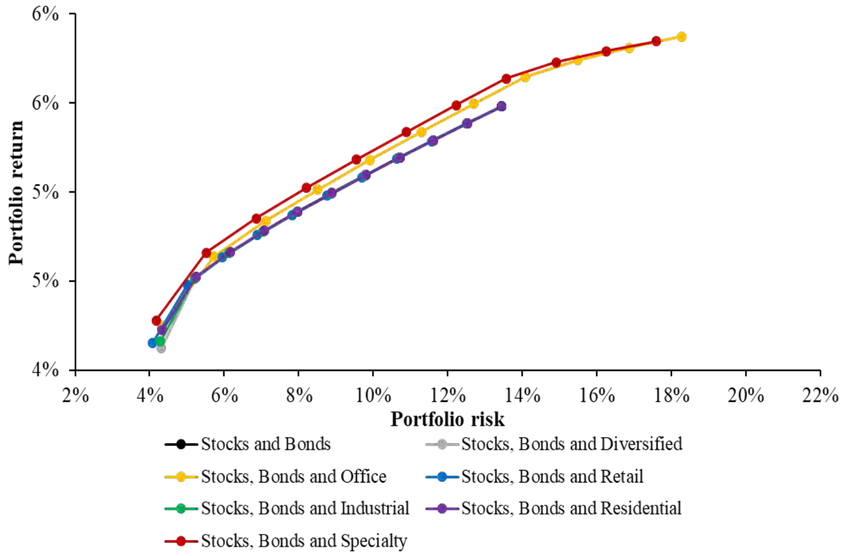
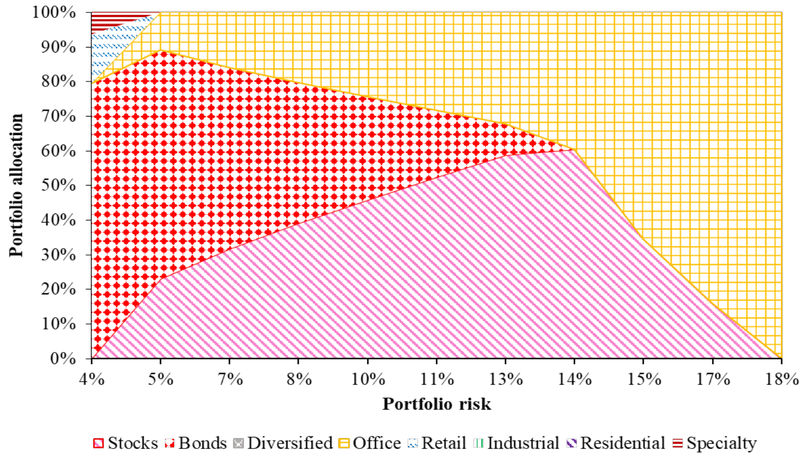


Table 5-12: Sector-specific A-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
0.0%	79.6%	0.0%	0.0%	14.1%	0.0%	0.0%	6.3%	4.20%	3.98%
23.2%	66.1%	0.0%	10.8%	0.0%	0.0%	0.0%	0.0%	4.59%	5.41%
31.7%	52.4%	0.0%	15.9%	0.0%	0.0%	0.0%	0.0%	4.80%	6.84%
39.0%	40.7%	0.0%	20.3%	0.0%	0.0%	0.0%	0.0%	4.98%	8.27%
45.8%	29.8%	0.0%	24.4%	0.0%	0.0%	0.0%	0.0%	5.15%	9.70%
52.3%	19.3%	0.0%	28.4%	0.0%	0.0%	0.0%	0.0%	5.32%	11.13%
58.7%	9.0%	0.0%	32.2%	0.0%	0.0%	0.0%	0.0%	5.48%	12.55%
60.4%	0.0%	0.0%	39.6%	0.0%	0.0%	0.0%	0.0%	5.64%	13.98%
34.6%	0.0%	0.0%	65.4%	0.0%	0.0%	0.0%	0.0%	5.74%	15.41%
16.0%	0.0%	0.0%	84.0%	0.0%	0.0%	0.0%	0.0%	5.81%	16.84%
0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	5.87%	18.27%

Figure 5-7: Sector-specific A-REIT asset allocation diagram: July 2006–December 2018



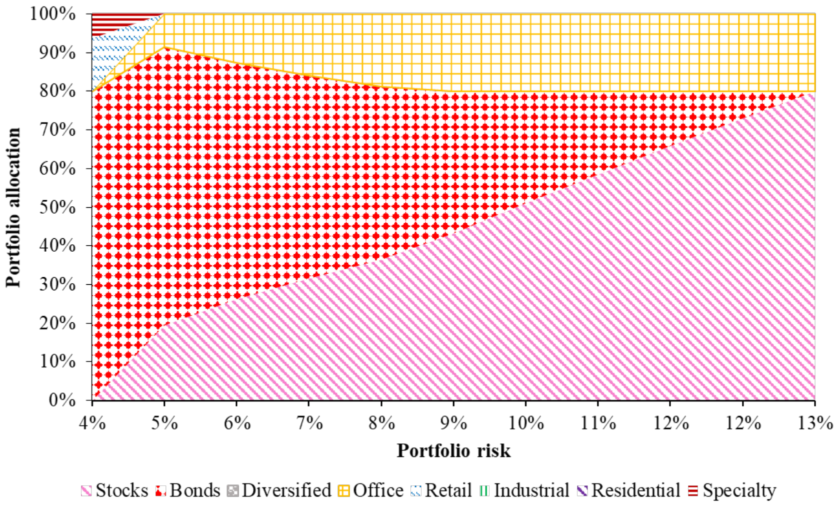
To avoid over-exposure in the property asset classes, a constrained mean-variance analysis was conducted for sector-specific A-REITs in the Australian mixed-asset portfolio over the whole study timeframe. The constrained allocation involved the imposition of a 20% exposure cap for combinations of sector-specific and diversified A-REITs. The constrained asset allocation findings are reported in **Table 5-13** and **Figure 5-8**. Consistently, office A-REITs (16.0%) accounted for a maximum level of 20% of the capped total property exposure in the mixed-asset portfolio, while retail (1.3%) and specialty A-REITs (0.6%) had a minor role in the lower end of the risk-return band. Since portfolio allocations for stocks and bonds were not constrained, the mainstream asset classes played more active roles in the constrained mixed-asset portfolio. Diversified A-REITs did not play any role in the constrained property components.

These analyses offer substantial empirical evidence of sector-specific A-REITs as a more significant component delivering higher portfolio returns in mixed-asset portfolios compared with their diversified counterparts over the entire study period. More importantly, this supports the existence of REIT specialisation value in Australia.

Table 5-13: Constrained sector-specific A-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
0.0%	80.0%	0.0%	0.0%	13.8%	0.0%	0.0%	6.2%	4.20%	3.98%
19.5%	72.0%	0.0%	8.5%	0.0%	0.0%	0.0%	0.0%	4.49%	4.92%
26.2%	61.2%	0.0%	12.6%	0.0%	0.0%	0.0%	0.0%	4.66%	5.87%
31.6%	52.5%	0.0%	15.9%	0.0%	0.0%	0.0%	0.0%	4.80%	6.82%
36.5%	44.7%	0.0%	18.8%	0.0%	0.0%	0.0%	0.0%	4.92%	7.76%
43.2%	36.8%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.04%	8.71%
50.9%	29.1%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.15%	9.66%
58.4%	21.6%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.25%	10.60%
65.7%	14.3%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.36%	11.55%
72.9%	7.1%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.46%	12.50%
80.0%	0.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	5.56%	13.44%

Figure 5-8: Constrained sector-specific A-REIT asset allocation diagram: July 2006–December 2018



5.3.5 Sub-period Analysis

Table 5-14 tabulates the risk-adjusted performance for sector-specific A-REITs, diversified A-REITs and the major asset classes over two sub-periods. Before the GFC, residential (1.88) and office A-REITs (1.48) outperformed diversified A-REITs (1.42) on a risk-adjusted return basis, while specialty (0.99), industrial (0.87) and retail A-REITs (0.83) were secondary to diversified A-REITs. After the GFC, most sector-specific A-REITs offered higher risk-adjusted returns than diversified A-REITs (0.64), except for retail A-REITs (0.55). Both sector-specific and diversified A-REITs underperformed stocks (3.96) before the GFC, since stocks provided the highest average annual returns (32.56%) and comparatively lower annual risk (6.61%) of all assets before the GFC. After the GFC, when stocks slumped to average annual returns of 7.64% and offered relatively higher annual risk (11.79%), both sector-specific and diversified A-REITs surpassed stocks (0.38) in terms of risk-adjusted returns. Moreover, both sector-specific REITs and diversified A-REITs were better risk-adjusted performers than bonds over the two sub-periods.

Table 5-14: Sector-specific A-REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Office	24.99	12.60	1.48	3
Retail	16.22	11.82	0.83	7
Industrial	17.67	12.93	0.87	6
Residential	28.06	11.55	1.88	2
Specialty	19.65	13.38	0.99	5
Diversified	26.19	13.95	1.42	4
Stocks	32.56	6.61	3.96	1
Bonds	5.85	0.65	−0.81	8
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Office	15.02	9.91	1.20	2
Retail	7.78	8.35	0.55	6
Industrial	16.19	11.65	1.12	3
Residential	13.76	15.31	0.69	4
Specialty	17.83	9.47	1.55	1
Diversified	12.07	14.00	0.64	5
Stocks	7.64	11.79	0.38	7
Bonds	3.56	3.83	0.11	8

Note: *Local currency

Table 5-15 shows the inter-asset correlation for sector-specific A-REITs, diversified A-REITs and the mainstream asset classes over two sub-periods. During two sub-periods, different property types of A-REITs (pre-GFC average $r = 0.28$; post-GFC average $r = 0.55$) featured stronger diversification benefits with stocks compared with diversified A-REITs ($r = 0.59$; $r = 0.67$). In terms of portfolio diversification benefits with bonds, sector-specific A-REITs ($r = -0.40$; $r = 0.02$) were second to diversified A-REITs ($r = -0.56$; $r = 0.00$) over two sub-periods. The only exception is specialty A-REITs

(r = .0.08) after the GFC. The results show consistent inter-asset correlations over two sub-periods. Diversification within each property type of A-REITs and diversified A-REITs (average r = 0.63) during the pre-GFC period was comparable with that in the post-GFC context (average r = 0.63). Nonetheless, diversification within various property types of A-REITs (average r = 0.32) was more attractive for investors before the GFC than after (average r = 0.47). In short, sector-specific A-REITs offered greater diversification benefits with stocks for property investors than did diversified A-REITs over the two sub-periods. However, sector-specific A-REITs provided lesser diversification benefits with bonds than did diversified A-REITs over the two sub-periods. Importantly, a sectoral A-REIT investment strategy could provide greater diversification benefits for Australian listed property investors compared with an inter-A-REIT investment strategy.

Table 5-15: Sector-specific A-REIT sub-period correlations analysis

Panel A: Pre-GFC: July 2006–September 2007								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.48*	1.00						
Diversified	0.59*	-0.56	1.00					
Office	0.37*	-0.28*	0.69*	1.00				
Retail	0.35*	-0.38	0.87*	0.65*	1.00			
Industrial	0.58*	-0.53	0.93*	0.61*	0.81*	1.00		
Residential	-0.17*	-0.36*	0.26*	0.13*	0.31*	0.08*	1.00	
Specialty	0.27*	-0.44	0.38*	0.19*	0.10*	0.19*	0.11*	1.00
Panel B: Post-GFC: July 2009–December 2018								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.40*	1.00						
Diversified	0.67*	-0.00*	1.00					
Office	0.67*	0.07*	0.79*	1.00				
Retail	0.50*	0.01*	0.72*	0.70*	1.00			
Industrial	0.61*	0.01*	0.71*	0.71*	0.63*	1.00		
Residential	0.48*	0.10*	0.48*	0.40*	0.37*	0.42*	1.00	
Specialty	0.47*	-0.08*	0.46*	0.41*	0.25*	0.49*	0.31*	1.00

Note: *Significant correlation ($p<5\%$)

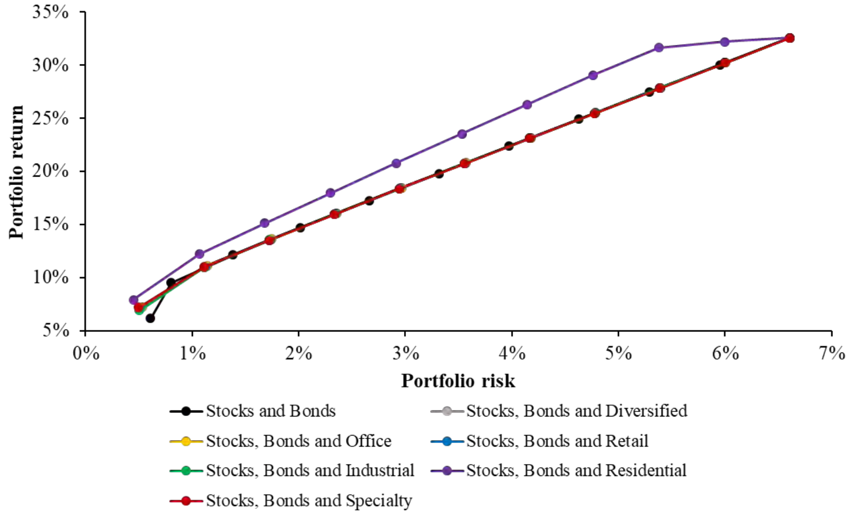
The constrained asset allocations and efficient frontiers for different property types of A-REITs for two sub-periods are reported in **Figure 5-9** and **Figure 5-10**, respectively. Before the GFC, efficient frontiers with the addition of each property type of A-REITs (average allocation = 12.1%) had a larger uplift than that for diversified A-REITs and the benchmark financial assets-only portfolio (stocks and bonds). These resulted in sector-specific A-REITs playing a primary role in the capped property compositions, while diversified A-REITs did not have any role in the constrained mixed-asset portfolio. Residential A-REITs dominated the whole risk-return band within the scope of the 20% capped total property allocation. Owing to the unconstrained portfolio allocation for the property asset class, stocks (52.5%) and bonds (35.4%) had more roles in structuring the capped allocation of the constrained multi-asset portfolio.

In the post-GFC context, industrial A-REITs (17.7%) became the dominant influence across the broad risk-return range within the scope of 20% capped total property allocation, followed by specialty (0.9%), retail (0.9%) and office A-REITs (0.5%) in the lower end of the risk-return band. There was no role for diversified A-REITs in the constrained portfolio components, while stocks (43.4%) and bonds (36.6%) were mainly configured in the constrained mixed-asset portfolio. In summary, the sub-period analysis suggests that different property types of A-REITs played a more significant role than diversified A-REITs over two sub-periods.

5.3.6 Summary of Findings

The summary of the empirical results for different property types of A-REITs is documented in **Table 5-16**. As presented in Panel A, different property types of A-REITs offered higher average annualised returns and lower annual risk levels in comparison to diversified A-REITs over the entire study timeframe, as well as the two sub-periods. This resulted in sector-specific A-REITs overtaking diversified A-REITs on a risk-adjusted return basis. As shown in Panel B, different property types of A-REITs provided more attractive diversification benefits with stocks than did diversified A-REITs over the whole study period, as well as the two sub-periods. Nevertheless, sector-specific A-REITs were second to diversified A-REITs in terms of portfolio diversification benefits with bonds simultaneously. Notably, different property types of A-REITs were shown as a distinct investment asset from diversified A-REITs on a risk-adjusted performance basis, as reported in Panel C. More importantly, sector-specific A-REITs were seen to be a more valuable asset in the Australian mixed-asset portfolios than diversified A-REITs over the full sample period, as well as the two sub-period timeframes, as displayed in Panel D.

Figure 5-9: Sector-specific A-REIT constrained asset allocation diagram and efficient frontiers: pre-GFC: July 2006–September 2007



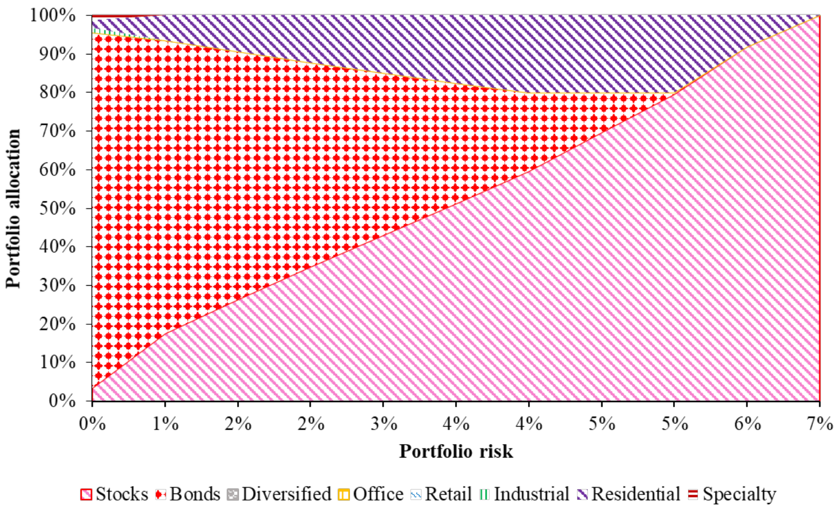
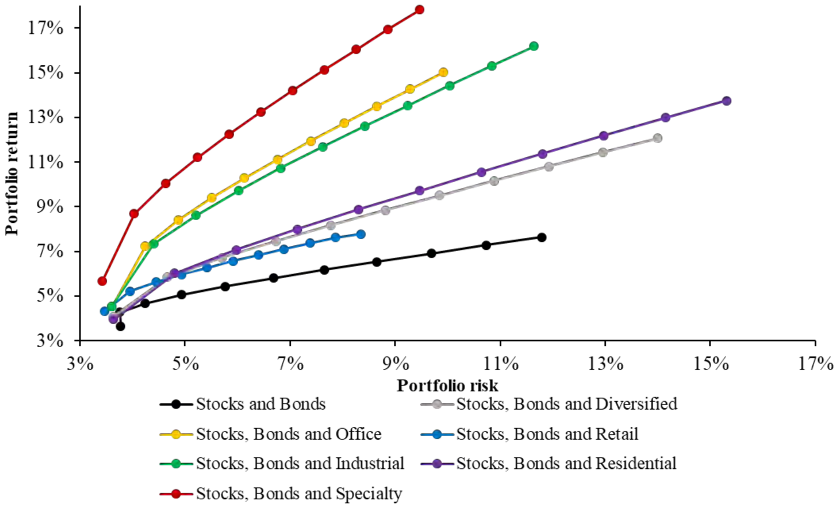


Figure 5-10: Sector-specific A-REIT constrained asset allocation diagram and efficient frontiers: post-GFC: July 2009–December 2018



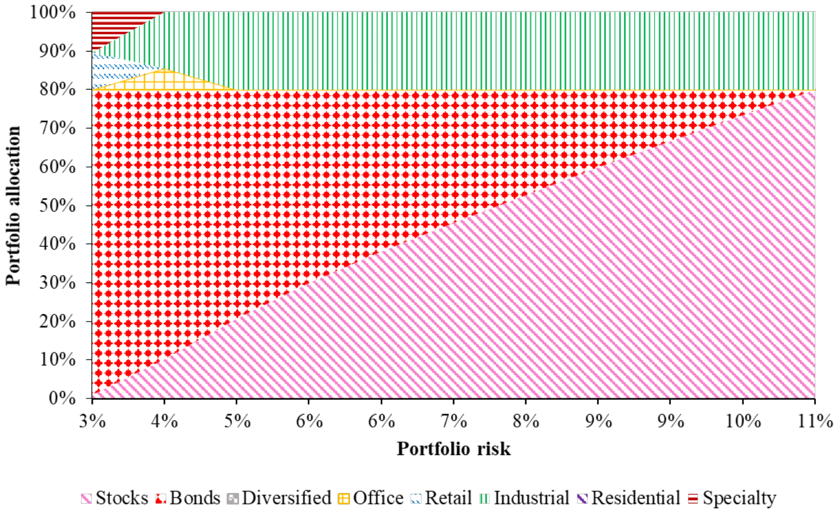


Table 5-16: Sector-specific A-REIT performance summary

Panel A: Return, risk and risk-adjusted return performance

Whole period	Asset	Return	Risk	Risk-adjusted return
1 versus	2	✔	✔	✔
	3	✗	✗	✗
	4	✔	✗	✔
Pre-GFC				
1 versus	2	✔	✔	✔
	3	✗	✗	✗
	4	✔	✗	✔
Post-GFC				
1 versus	2	✔	✔	✔
	3	✔	✔	✔
	4	✔	✗	✔

Panel B: Portfolio diversification benefits

Whole period	**1-3**	**1-4**	2-3	2-4	**1-2**
Average r =	**0.60**	**−0.13**	0.66	−0.13	**0.69**
Pre-GFC					
Average r =	**0.28**	**−0.40**	0.59	−0.56	**0.63**
Post-GFC					
Average r =	**0.55**	**0.02**	0.67	−0.00	**0.63**

Panel C: Risk-adjusted performance comparison

Whole period	Office	Retail	Industrial	Residential	Specialty
Significant different from Diversified	✔	✔	✔	✔	✔

Panel D: Asset allocation

Whole period	**1**	2	3	4
Average allocation	**40.2%**	0.0%	32.9%	27.0%
Pre-GFC				
Average allocation	**12.4%**	0.0%	52.2%	35.3%
Post-GFC				
Average allocation	**71.1%**	0.0%	0.0%	28.9%

Note: 1 = sector-specific REITs, 2 = diversified REITs, 3 = stocks, 4 = bonds

5.4 PERFORMANCE OF SINGAPORE SECTOR-SPECIFIC REITs

5.4.1 Risk-adjusted Performance Analysis

Table 5-17 displays the comparisons between sector-specific S-REITs, diversified S-REITs, stocks and bonds in terms of risk-adjusted performance from July 2006 to December 2018. Specialty S-REITs (13.35% p.a.) was the only sector-specific REITs posting higher average annual returns than diversified S-REITs (9.80% p.a.). The other sector-specific S-REITs offered lower average annual returns than diversified S-REITs, including industrial (8.31% p.a.), retail (7.61% p.a.), residential (6.56% p.a.) and office S-REITs (5.12% p.a.). Interestingly, both sector-specific and diversified S-REITs featured higher average annual returns than stocks (6.11% p.a.) and bonds (2.32% p.a.) over the full study period. The only exception was office S-REITs, underperforming stocks but being superior to bonds. The risk level for sector-specific S-REITs (average annual risk = 21.95%) was comparatively lower than for diversified S-REITs (27.41%) – retail (18.75%), industrial (19.19%), residential (23.62%), specialty (23.81%) and office S-REITs (24.36%) – over the entire study period. Visibly, both sector-specific and diversified S-REITs had higher volatility than stocks (18.34%) and bonds (1.66%). On a risk-adjusted return basis (via the Sharpe ratio), specialty (0.52), industrial (0.38) and retail S-REITs (0.35) outpaced diversified S-REITs (0.32), while residential and office S-REITs were inferior to diversified S-REITs over the last 12 years. As bonds (0.77) were the best risk-adjusted performer in the Singapore investment frame, both sector-specific and diversified S-REITs underperformed bonds over the study period. Nevertheless, sector-specific and diversified S-REITs surpassed stocks (0.28), except for residential and office S-REITs. The analysis indicates that different property types of REITs were generally superior to diversified S-REITs on a risk-adjusted return basis from July 2006 to December 2018.

Table 5-17: Sector-specific S-REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
REITs				
Office	5.12	24.36	0.17	8
Retail	7.61	18.75	0.35	4
Industrial	8.31	19.19	0.38	3
Residential	6.56	23.62	0.23	7
Specialty	13.35	23.81	0.52	2
Diversified	9.80	27.41	0.32	5
Stocks	6.11	18.34	0.28	6
Bonds	2.32	1.66	0.77	1

Note: *Local currency

5.4.2 Diversification Benefit Analysis

Table 5-18 presses the inter-asset correlation matrix for sector-specific S-REITs, diversified S-REITs, stocks and bonds from July 2006 to December 2018. Different property types of S-REITs (average $r = 0.79$) delivered stronger diversification benefits with stocks than did diversified S-REITs ($r = 0.83$), including specialty ($r = 0.56$), industrial ($r = 0.79$), retail ($r = 0.79$), residential ($r = 0.82$) and office S-REITs ($r = 0.83$). In terms of portfolio diversification benefits with bonds, most sector-specific S-REITs – namely office ($r = -0.21$), industrial ($r = -0.17$), retail ($r = -0.17$) and residential S-REITs ($r = -0.13$) – were superior to diversified S-REITs ($r = -0.11$) over the entire study period; the exception was specialty S-REITs ($r = -0.04$). In terms of an inter-property investment strategy, diversification within each property type of S-REITs and diversified S-REITs (average $r = 0.75$) was not attractive, and nor was diversification within various property types of S-REITs (average r = 0.76). The results show that different property types of S-REITs generally delivered greater portfolio diversification benefits than both stocks and bonds over the past 12 years than did diversified S-REITs. Apart from Japan and Australia, a sectoral S-REIT investment strategy was incomparable with an inter-S-REIT investment strategy for investors seeking portfolio diversifying in Singapore over the full study period.

Table 5-18: Sector-specific S-REIT correlations analysis: July 2006–December 2018

	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.10	1.00						
Diversified	0.83*	-0.11	1.00					
Office	0.83*	-0.21*	0.78*	1.00				
Retail	0.79*	-0.17*	0.77*	0.82*	1.00			
Industrial	0.79*	-0.17*	0.73*	0.76*	0.81*	1.00		
Residential	0.82*	-0.13	0.79*	0.82*	0.75*	0.74*	1.00	
Specialty	0.77*	-0.04	0.70*	0.73*	0.74*	0.69*	0.79*	1.00

Note: *Significant correlation (p<5%)

5.4.3 Risk-adjusted Performance Comparison Analysis

Table 5-19 lists the risk-adjusted return comparison results for different property types of REITs and diversified S-REITs from July 2006 to December 2018. Different property types of S-REITs are statistically significant at the 1% level over the full sample period. The results clarify that each property type of S-REIT was significantly different from diversified S-REITs in their Sharpe ratio. Specialty (Z value = 83.28), industrial (26.20) and retail S-REITs (13.86) posted higher risk-adjusted returns than diversified S-REITs, since the values of the Z-test statistics for these three assets are positive and statistically significant at the 1% level. Conversely, office and residential S-REITs registered lower risk-adjusted returns than diversified S-REITs, as the Z-test statistics of these two assets were negative and statistically significant at the 1% level.

Briefly, the analysis reveals that different property types of S-REITs were a significantly distinct investment asset from diversified S-REITs on a risk-return basis. Importantly, this validates the existence of REIT specialisation value in Singapore for property investors seeking listed property exposure in Singapore over the full study period.

Table 5-19: Risk-adjusted performance comparison between sector-specific and diversified S-REITs: July 2006–December 2018

Portfolio	Office and Diversified	Retail and Diversified
Z-test	−102.35***	13.86***
Portfolio	Industrial and Diversified	Residential and Diversified
Z-test	26.20***	−46.12***
Portfolio	Specialty and Diversified	
Z-test	83.28***	

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

5.4.4 Mixed-asset Portfolio Analysis

Figure 5-11 illustrates the efficient frontiers for various combinations from July 2006 to December 2018, with a special focus on the inclusion of different property types of S-REITs. The addition of different property types of S-REITs in a portfolio comprising financial assets (stocks and bonds) markedly boosted the efficient frontier curve compared with that for diversified S-REITs and a benchmark financial assets-only portfolio over the study period. Specifically, the efficient frontiers with the respective inclusion of specialty, industrial and retail S-REITs were higher than for diversified S-REITs and the baseline financial asset-only portfolio. On the other hand, the respective addition of residential and office S-REITs was lower than diversified S-REITs and was comparable with the benchmark portfolio.

Table 5-20 reports the mean-variance optimisation of different property types of S-REITs in a domestic mixed-asset portfolio over the study timeframe, and **Figure 5-12** depicts an asset composition diagram for the risk-return band. Sector-specific S-REITs (average allocation = 38.4%) overshadowed the entire risk-return range, particularly from the middle to the upper end of the risk-return scale when the risk level surged. Specifically, industrial (33.1%), retail (5.2%) and office S-REITs (0.1%) complemented bonds (33.0%) in the lower end of the risk-return range, while stocks had no portfolio allocation in the optimal mixed-asset portfolio. With the second-highest average annual returns and highest annual risk level of all assets, diversified S-REITs (28.5%) featured in the higher end of the risk-return scale, gradually overshadowing industrial S-REITs at the end of the risk-return scale as a high-risk investment asset.

Figure 5-11: Sector-specific S-REIT efficient frontiers: July 2006–December 2018

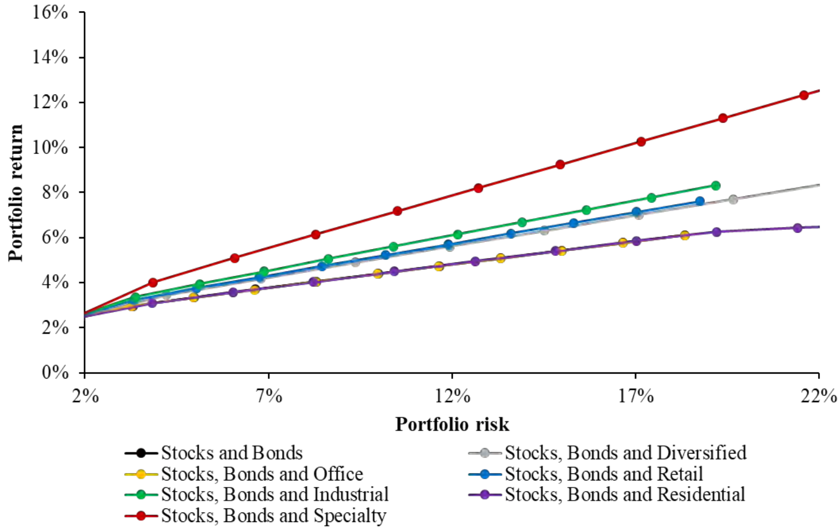
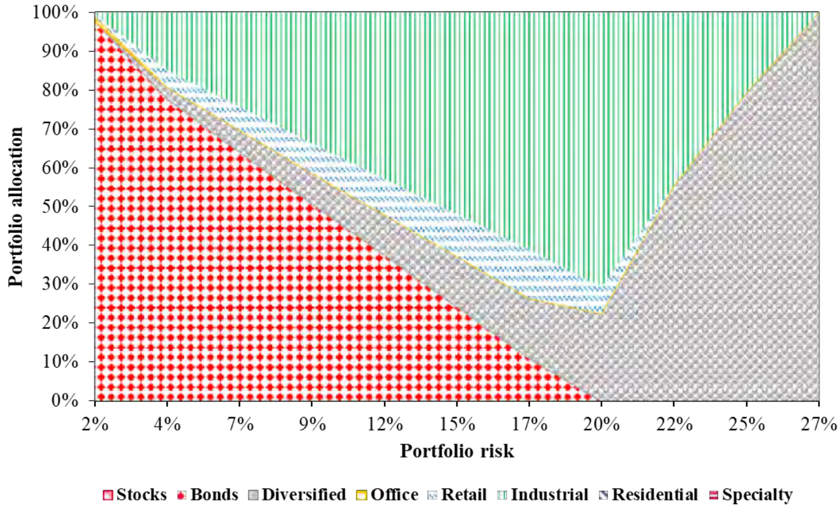


Table 5-20: Sector-specific S-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
0.0%	97.8%	0.0%	1.2%	0.4%	0.6%	0.0%	0.0%	2.41%	1.60%
0.0%	77.9%	3.0%	0.0%	4.2%	14.8%	0.0%	0.0%	3.66%	4.18%
0.0%	64.1%	5.6%	0.0%	5.9%	24.3%	0.0%	0.0%	4.51%	6.76%
0.0%	50.7%	8.1%	0.0%	7.6%	33.6%	0.0%	0.0%	5.34%	9.34%
0.0%	37.4%	10.6%	0.0%	9.2%	42.8%	0.0%	0.0%	6.16%	11.92%
0.0%	24.2%	13.1%	0.0%	10.8%	51.9%	0.0%	0.0%	6.98%	14.50%
0.0%	11.0%	15.5%	0.0%	12.5%	61.0%	0.0%	0.0%	7.80%	17.08%
0.0%	0.0%	22.7%	0.0%	6.7%	70.6%	0.0%	0.0%	8.60%	19.66%
0.0%	0.0%	55.6%	0.0%	0.0%	44.4%	0.0%	0.0%	9.14%	22.24%
0.0%	0.0%	79.6%	0.0%	0.0%	20.4%	0.0%	0.0%	9.50%	24.82%
0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.80%	27.41%

Figure 5-12: Sector-specific S-REIT asset allocation diagram: July 2006–December 2018

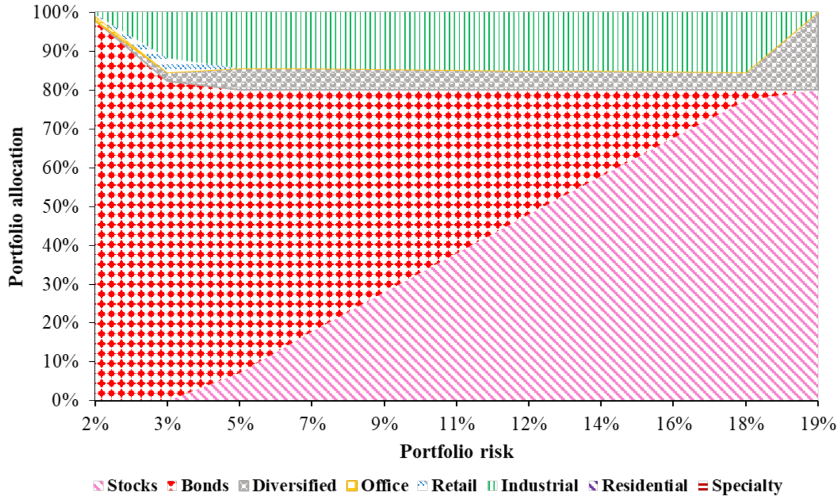


Given that there was no portfolio composition for stocks, this trend was not common within institutional investor portfolio holdings. To avoid over-exposure in the property asset classes, a constrained mean-variance analysis was undertaken for different property types of S-REITs in the Singapore mixed-asset portfolio over the full study timeframe. The constrained mean-variance portfolio analysis imposes a 20% cap on property asset classes. **Table 5-21** and **Figure 5-13** document the results of the constrained mixed-asset portfolio for sector-specific S-REITs. The imposition of the cap on the total property asset classes drove significant reductions in overall portfolio expected returns and risk level. Industrial S-REITs (12.0%) were the dominant asset across the full risk-return band within the scope of 20% capped portfolio composition, followed by diversified (5.7%), retail (0.4%) and office S-REITs (0.1%). As a high-risk investment asset, diversified S-REITs mainly featured at the end of the risk-return range. Since the mainstream asset classes were unconstrained, stocks (38.3%) and bonds (43.5%) played more active roles in shaping the constrained mixed-asset portfolio compositions. These analyses confirm sector-specific S-REITs are a more significant portfolio enhancer, despite some role for diversified S-REITs in the higher end of the risk-return scale as a high-risk investment asset.

Table 5-21: Constrained sector-specific S-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
0.0%	97.8%	0.0%	1.2%	0.4%	0.6%	0.0%	0.0%	2.41%	1.60%
0.0%	82.3%	2.2%	0.0%	3.7%	11.7%	0.0%	0.0%	3.38%	3.38%
7.2%	72.8%	5.6%	0.0%	0.0%	14.4%	0.0%	0.0%	3.87%	5.17%
17.8%	62.2%	5.5%	0.0%	0.0%	14.5%	0.0%	0.0%	4.27%	6.96%
28.0%	52.0%	5.3%	0.0%	0.0%	14.7%	0.0%	0.0%	4.66%	8.74%
38.0%	42.0%	5.2%	0.0%	0.0%	14.8%	0.0%	0.0%	5.03%	10.53%
47.9%	32.1%	5.0%	0.0%	0.0%	15.0%	0.0%	0.0%	5.41%	12.31%
57.8%	22.2%	4.9%	0.0%	0.0%	15.1%	0.0%	0.0%	5.78%	14.10%
67.6%	12.4%	4.7%	0.0%	0.0%	15.3%	0.0%	0.0%	6.15%	15.89%
77.3%	2.7%	4.6%	0.0%	0.0%	15.4%	0.0%	0.0%	6.52%	17.67%
80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.85%	19.46%

Figure 5-13: Constrained sector-specific S-REIT asset allocation diagram: July 2006–December 2018



5.4.5 Sub-period Analysis

Table 5-22 exhibits the risk-adjusted performance of sector-specific S-REITs, diversified S-REITs and the mainstream asset classes over two sub-periods. Before the GFC, most sector-specific S-REITs posted lower risk-adjusted returns than diversified S-REITs (2.49) owing to their comparatively higher annual risk level (average risk = 24.22%) compared with diversified S-REITs (19.99%). The only exception was specialty S-REITs (3.33), since it had the highest average annual returns (112.52% p.a.) of all assets. After the GFC, most sector-specific S-REITs registered higher risk-adjusted returns than diversified S-REITs (0.67) on account of their relatively lower risk level (average risk = 12.92%) compared with diversified S-REITs (16.97%). Residential S-REITs (0.59) was the exception because of their lower average annual returns (8.38% p.a.). Before the GFC, both sector-specific and diversified S-REITs underperformed stocks (4.23), since stocks provided the second-highest average annual returns at 53.09% p.a. and the second-lowest average risk of 11.84% among all assets. After the GFC, both sector-specific and diversified S-REITs were clearly superior to stocks (0.40), since stocks offered the second-lowest average annual returns among all assets. Both sector-specific and diversified S-REITs surpassed bonds on a risk-adjusted return basis before the GFC, since bonds offered the lowest risk-adjusted performance of all assets. After the GFC, bonds outpaced both sector-specific and diversified S-REITs in terms of risk-adjusted returns since average risk levels for sector-specific and diversified S-REITs were visibly riskier than bonds.

Table 5-23 illustrates the inter-asset correlation for sector-specific S-REITs, diversified S-REITs and the major asset classes over the two sub-periods. Most sector-specific S-REITs (pre-GFC average $r = 0.61$; post-GFC average $r = 0.66$) featured more alluring diversification benefits with stocks than did diversified S-REITs ($r = 0.69$; $r = 0.70$). The exceptions were retail ($r = 0.74$) and industrial S-REITs (0.81) before the GFC, and office S-REITs ($r = 0.74$) after the GFC. In terms of portfolio diversification benefits with bonds, most sector-specific S-REITs (pre-GFC average $r = 0.09$; post-GFC average $r = -0.18$) were more appealing than diversified S-REITs ($r = 0.19$; $r = -0.18$) over two sub-periods, except for residential ($r = 0.25$; $r = -0.12$) and specialty S-REITs ($r = 0.22$; $r = -0.14$). The results are consistent on inter-asset correlations over the two sub-periods. Diversification within each property type of S-REITs and diversified S-REITs (average $r = 0.57$) during the pre-GFC period was desirable (average $r = 0.67$) in the post-GFC context. Diversification within various property types of S-REITs (average $r = 0.58$) before the GFC was more attractive for investors than after the GFC (average $r = 0.65$). Briefly, sector-specific S-REITs offered more attractive diversification benefits with both stocks and bonds for property investors than did diversified S-REITs over the two sub-periods. Importantly, the effect of a sectoral S-REIT investment strategy was more significant in the post-GFC context for Singapore listed property investors seeking portfolio diversification benefits compared with an inter-S-REIT investment strategy.

Table 5-22: Sector-specific S-REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Office	40.20	18.71	1.99	6
Retail	51.13	20.68	2.33	5
Industrial	38.25	24.73	1.42	7
Residential	60.30	24.04	2.38	4
Specialty	112.52	32.92	3.33	2
Diversified	52.88	19.99	2.49	3
Stocks	53.09	11.84	4.23	1
Bonds	3.01	0.69	−0.04	8
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Office	10.85	14.02	0.72	5
Retail	10.54	11.80	0.83	3
Industrial	11.33	12.12	0.87	2
Residential	8.38	12.93	0.59	7
Specialty	11.26	13.73	0.77	4
Diversified	12.06	16.97	0.67	6
Stocks	5.64	12.29	0.40	8
Bonds	2.17	1.38	1.04	1

Note: *Local currency

Table 5-23: Sector-specific S-REIT sub-period correlations analysis

Panel A: Pre-GFC: July 2006–September 2007								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.11*	1.00						
Diversified	0.69*	0.19*	1.00					
Office	0.58*	-0.01*	0.71*	1.00				
Retail	0.74*	0.13*	0.59*	0.65*	1.00			
Industrial	0.81*	-0.14*	0.62*	0.63*	0.63*	1.00		
Residential	0.54*	0.25*	0.61*	0.71*	0.66*	0.55*	1.00	
Specialty	0.37*	0.22*	0.32*	0.35*	0.54*	0.56*	0.51*	1.00
Panel B: Post-GFC: July 2009–December 2018								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.16	1.00						
Diversified	0.70*	-0.18	1.00					
Office	0.74*	-0.21	0.75*	1.00				
Retail	0.66*	-0.24	0.68*	0.75*	1.00			
Industrial	0.60*	-0.20	0.58*	0.69*	0.75*	1.00		
Residential	0.63*	-0.12	0.71*	0.67*	0.57*	0.53*	1.00	
Specialty	0.67*	-0.14	0.64*	0.68*	0.60*	0.60*	0.69*	1.00

Note: *Significant correlation (p<5%)

The constrained asset allocations and efficient frontiers for sector-specific S-REITs for two sub-periods are pressed in **Figure 5-14** and **Figure 5-15**, respectively. Before the GFC, sector-specific S-REITs played a minor role (average allocation = 2.3%) in the constrained mixed-asset portfolio at the high-risk level, while stocks (53.2%) and bonds (44.5%) dominated the broad risk-return scale. However, residential S-REITs accounted for a maximum level of 20% in the capped portfolio compositions to the property asset classes, while there was no role for diversified S-REITs.

In the post-GFC timeframe, the prominent role of sector-specific S-REITs (15.8%) was presented across the broad risk-return scale within the scope of 20% capped portfolio allocations, while diversified S-REITs (2.7%) only featured at either end of the risk-return range. Specifically, industrial REITs overshadowed the scope of 20% constraint on the property asset allocations since it offered the second-highest annual returns and second-lowest volatility of all assets. However, diversified S-REITs mainly featured at the end of the risk-return band as the investment asset with the highest risk level. Because the mainstream asset classes were unconstrained, stocks (41.2%) and bonds (40.3%) played more active roles in the constrained mixed-asset portfolio compositions.

5.4.6 Summary of Findings

Table 5-24 summarises the empirical results for different property types of S-REITs from July 2006 to December 2018, as well as the two sub-periods. As shown in Panel A, sector-specific S-REITs generally registered higher average annual returns and lower risk level than diversified S-REITs over the full sample period and two sub-periods. This indicates that sector-specific S-REITs were superior to diversified S-REITs on a risk-adjusted return basis. Moreover, different property types of S-REITs provided greater diversification benefits with both stocks and bonds than did diversified S-REITs, as seen in Panel B. Importantly, sector-specific S-REITs featured distinct risk-return attributes from diversified S-REITs, as displayed in Panel C. This led to sector-specific S-REITs playing a larger role in the mixed-asset portfolios than diversified S-REITs over the whole sample period and sub-periods, particularly before the GFC. Despite the fact that diversified S-REITs provided the highest annual returns in the post-GFC timeframe, sector-specific S-REITs still dominated the mixed-asset portfolio as they offered comparable annual returns and lower risk level for investors, as displayed in Panel D.

Figure 5-14: Sector-specific S-REIT constrained asset allocation diagram and efficient frontiers: pre-GFC: July 2006–September 2007

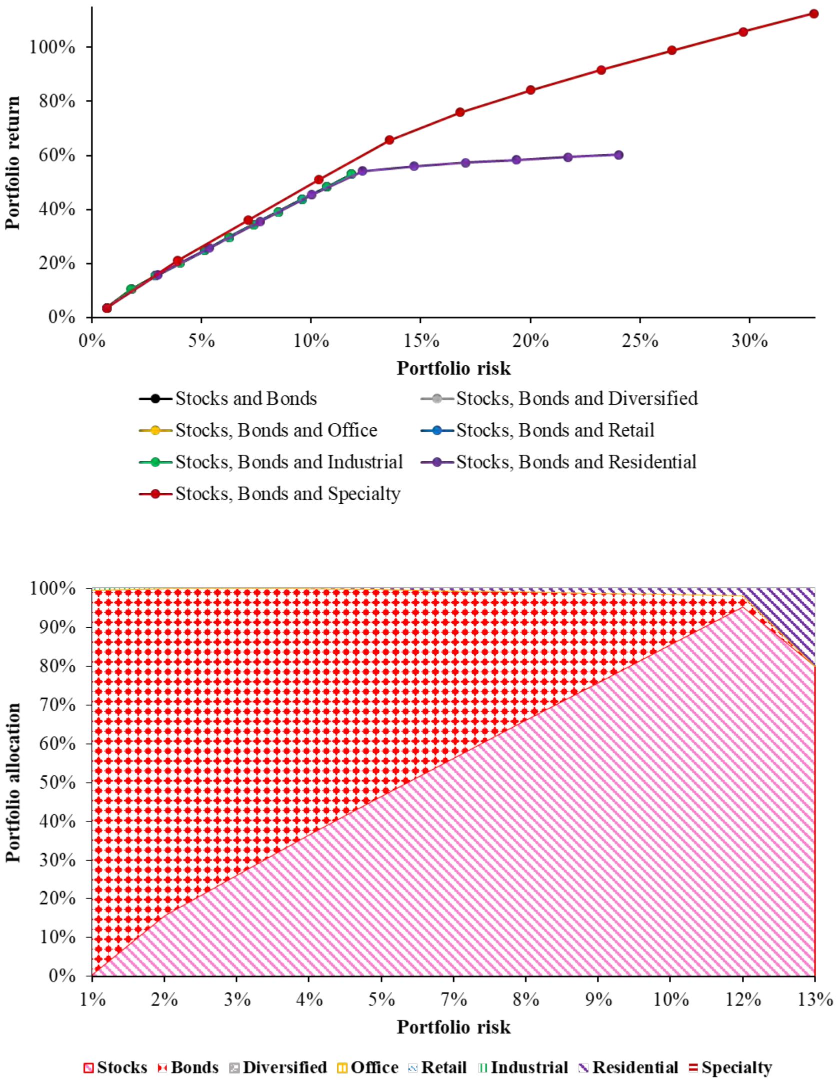


Figure 5-15: Sector-specific S-REIT constrained asset allocation diagram and efficient frontiers: post-GFC: July 2009–December 2018

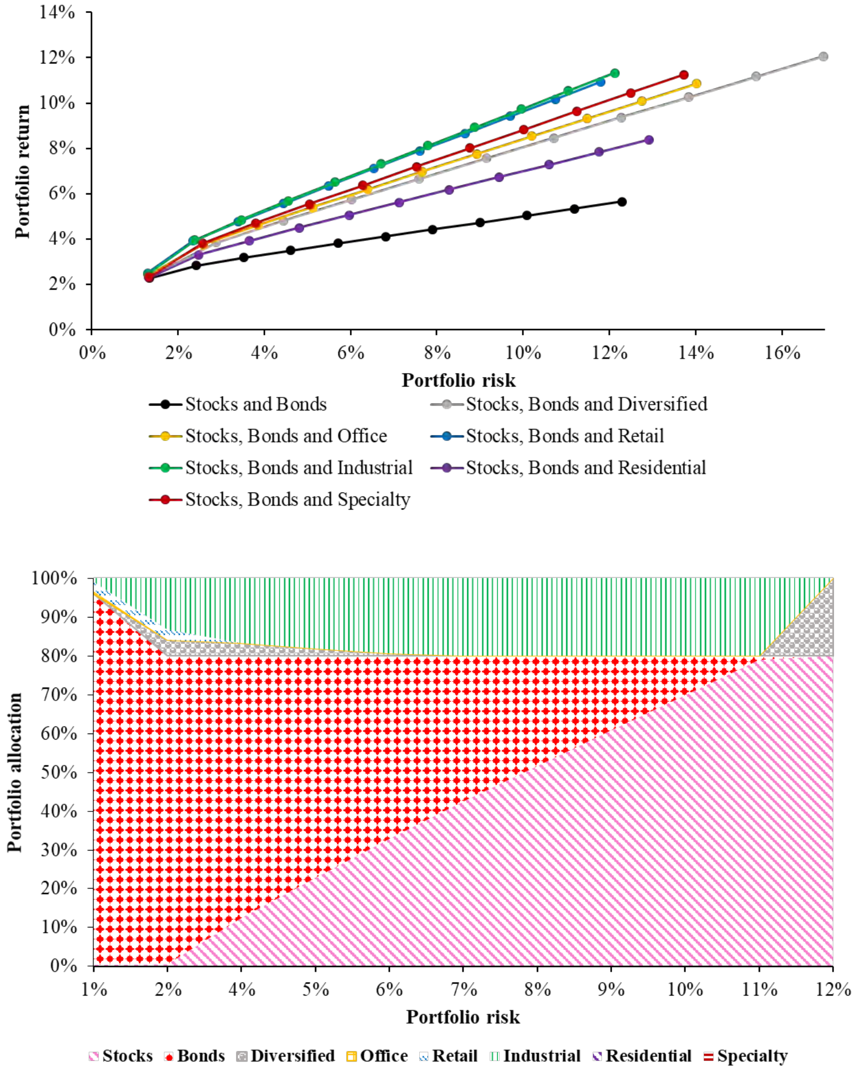


Table 5-24: Sector-specific S-REIT performance summary

Panel A: Return, risk and risk-adjusted return performance

Whole period	Asset	Return	Risk	Risk-adjusted return
1 versus	2	✔	✔	✔
	3	✔	✕	✔
	4	✔	✕	✕
Pre-GFC				
1 versus	2	✔	✔	✔
	3	✔	✕	✕
	4	✔	✕	✔
Post-GFC				
1 versus	2	✕	✔	✔
	3	✔	✕	✔
	4	✔	✕	✕

Panel B: Portfolio Diversification benefits

Whole period	**1-3**	**1-4**	2-3	2-4	**1-2**
Average r =	**0.79**	**−0.14**	0.83	−0.11	**0.75**
Pre-GFC					
Average r =	**0.61**	**0.09**	0.69	0.19	**0.57**
Post-GFC					
Average r =	**0.66**	**−0.18**	0.70	−0.18	**0.67**

Panel C: Risk-adjusted performance comparison

All timeframe	Office	Retail	Industrial	Residential	Specialty
Significant different from Diversified	✔	✔	✔	✔	✔

Panel D: Asset allocation

Whole period	**1**	2	3	4
Average allocation	**38.4%**	28.5%	0.0%	33.0%
Pre-GFC				
Average allocation	**33.9%**	0.0%	40.8%	25.3%
Post-GFC				
Average allocation	**40.9%**	0.0%	0.0%	30.3%

Note: 1 = sector-specific REITs, 2 = diversified REITs, 3 = stocks, 4 = bonds

5.5 SUMMARY OF FINDINGS

This chapter investigates the performance and significance of Asia-Pacific REIT sub-sectors (diversified, office, retail, industrial, residential and specialty REITs) across Japan, Australia and Singapore. The statistical analyses comprise the risk-adjusted performance, portfolio diversification benefits, risk-adjusted performance comparisons, roles in domestic mixed-asset portfolios and sub-period analysis from July 2006 to December

2018. The risk-adjusted performance and portfolio analyses are measured by monthly total return indices of domestic REIT sub-sectors, stocks and bonds across various domestic jurisdictions. The primary empirical results are as follows.

5.5.1 Risk-adjusted Performance

The results from this chapter illustrate that sector-specific REITs were generally superior to diversified REITs, stocks and bonds in their respective domestic investment markets on a risk-adjusted return basis (**Table 5-25**). The only two exceptions were the lesser risk-adjusted returns of sector-specific A-REITs compared with stocks in Australia, and that for sector-specific S-REITs compared with bonds in Singapore. The full period results were strengthened by the post-GFC outcomes, but differed slightly from the pre-GFC findings. Prior to the GFC, sector-specific REITs surpassed diversified REITs and bonds across Japan, Australia and Singapore on a risk-adjusted return basis, but underperformed stocks in the respective domestic investment markets. Post the GFC, stronger risk-adjusted returns of sector-specific REITs was witnessed across these three markets compared with diversified REITs, stocks and bonds in the respective domestic investment contexts. The only exception was sector-specific S-REITs, which were inferior to bonds in Singapore on a risk-adjusted return basis. In short, different property types of REITs were generally the superior risk-adjusted performer compared with diversified REITs, stocks and bonds across various domestic jurisdictions in the Asia-Pacific, due to higher annual returns and lower annual risk levels from July 2006 to December 2018.

While the preceding results show that different property types of REITs offered stronger risk-adjusted returns compared with their diversified counterparts across Japan, Australia and Singapore over the study period, it is unclear whether risk-adjusted returns of various property types of REITs and diversified REITs are statistically and significantly different. The risk-adjusted performance comparison results are depicted in **Table 5-26**. Different property types of REITs were statistically significant at the 1% level over the whole sample period. In brief, this highlights that sector-specific REITs were empirically different investment assets from diversified REITs across Japan, Australia and Singapore.

Table 5-25: Asia-Pacific sector-specific REIT performance summary: domestic

Did sector-specific REITs offer better performance compared with domestic asset classes?				
	Asset	Return	Risk	Risk-adjusted return
Panel A: Whole period				
Japan	1	✔	✗	✔
	2	✔	✗	✔
	3	✔	✗	✔
Australia	1	✔	✔	✔
	2	✔	✗	✗
	3	✔	✗	✔
Singapore	1	✔	✔	✔
	2	✔	✗	✔
	3	✔	✗	✗
Panel B: Pre-GFC				
Japan	1	✔	✔	✔
	2	✔	✗	✗
	3	✔	✗	✔
Australia	1	✔	✔	✔
	2	✗	✗	✗
	3	✔	✗	✔
Singapore	1	✔	✔	✔
	2	✔	✗	✗
	3	✔	✗	✔
Panel C: Post-GFC				
Japan	1	✔	✔	✔
	2	✔	✔	✔
	3	✔	✗	✔
Australia	1	✔	✔	✔
	2	✔	✔	✔
	3	✔	✗	✔
Singapore	1	✗	✔	✔
	2	✔	✗	✔
	3	✔	✗	✗

Note: 1 = diversified REITs, 2 = stocks, 3 = bonds

Table 5-26: Risk-adjusted performance comparison summary for Asia-Pacific – Sector-specific and diversified REIT: domestic

	1-6	2-6	3-6	4-6	5-6
Japan	✔*	✔*	✔*	✔*	✔*
Australia	✔*	✔*	✔*	✔*	✔*
Singapore	✔*	✔*	✔*	✔*	✔*

Note: 1 = office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty, 6-diversified REITs
* = significant at 1% level

5.5.2 Portfolio Diversification Benefits

In terms of the portfolio diversification potential, the empirical evidence from this chapter indicates that sector-specific REITs presented stronger diversification benefits with stocks compared with their diversified counterparts across these three markets in the Asia-Pacific over the entire study period, including two sub-periods (**Table 5-27**). Lower diversification benefits with bonds for sector-specific REITs compared with diversified REITs were reported in the post-GFC investment context. During the pre-GFC period, different property types of REITs generally offered more attractive portfolio diversification benefits than bonds than did diversified REITs in Japan and Singapore. Unlike Japan and Singapore, different property types of REITs were inferior to diversified REITs in the Australian investment context.

Two interesting findings have emerged in this chapter. Firstly, in terms of an inter-property investment strategy, diversification within each property type of REITs and diversified REITs was not desirable across Japan, Australia and Singapore over the full sample period, including two sub-periods. However, diversification within various property types of REITs was generally more attractive for investors compared with diversifications within all REIT sub-sectors across these three markets over the entire study period. The only exception is Singapore. This is due to that diversified REITs comprise a property portfolio with multiple property sectors. This highlights that a sectoral REIT investment strategy could provide greater diversification benefits for Asia-Pacific listed property investors compared with an inter-REIT investment strategy.

Secondly, the time-varying results are shown in **Table 5-27**. In general, Asia-Pacific sector-specific REITs had a higher level of correlations with both stocks and bonds after the GFC compared with their pre-GFC levels. Time-varying inter-property correlations have been identified. Both a sectoral REIT investment strategy and an inter-REIT diversification strategy were less appealing in the post-GFC environment compared with their pre-GFC performance. This indicates that the post-GFC portfolio diversification benefits of Asia-Pacific sector-specific REITs were not comparable with their pre-GFC levels, or with diversified REITs in the region.

Table 5-27: Asia-Pacific sector-specific REIT correlation coefficient summary: domestic

	1-3	2-3	1-4	2-4	1-2	1-1
Panel A: Whole period						
Japan	0.51	0.63	−0.06	−0.07	0.79	0.65
Australia	0.60	0.66	−0.13	−0.13	0.69	0.57
Singapore	0.79	0.83	−0.14	−0.11	0.75	0.76
Panel B: Pre-GFC						
Japan	0.50	0.52	−0.50	−0.42	0.78	0.68
Australia	0.28	0.59	−0.40	−0.56	0.63	0.32
Singapore	0.61	0.69	0.09	0.19	0.57	0.58
Panel C: Post-GFC						
Japan	0.45	0.55	0.07	0.03	0.82	0.74
Australia	0.55	0.67	0.02	0.00	0.63	0.47
Singapore	0.66	0.70	−0.18	−0.18	0.67	0.65

Note: 1 = sector-specific REITs, 2 = diversified REITs, 3 = stocks, 4 = bonds

5.5.3 Role in Domestic Mixed-asset Portfolios

The role of different property types of REITs in domestic mixed-asset portfolios across Japan, Australia and Singapore was assessed over the full sample period, including two sub-periods (**Table 5-28**). Compared with the mainstream asset classes (stocks and bonds), sector-specific REITs in Japan (57.9%), Australia (40.2%) and Singapore (38.4%) were optimally configured across the entire risk-return spectrum, complementing portfolio compositions of stocks and bonds when the risk level soared. It should be noted that sector-specific REITs played a more prominent role than diversified REITs, stocks and bonds in domestic mixed-asset portfolios across various domestic jurisdictions. This implies sector-specific REITs were an added-value and strategic portfolio component for both risk-averse and risk-taking investors over the past 12 years.

Time-varying portfolio allocations are shown in **Table 5-28**. Pre-GFC, sector-specific REITs in Japan (15.5%), Australia (12.4%) and Singapore (33.9%) had lower portfolio composition than either stocks or bonds in the respective domestic investment contexts. Meanwhile, diversified REITs did not play any role across the risk-return band. However, sector-specific REITs in Japan (60.6%), Australia (71.1%) and Singapore (40.9%) dominated the spectrum, while bonds were present in the lower end. At the same time, diversified REITs did not play any role in Japan and Australian mixed-asset portfolios, although they played some role in Singapore. In brief, investors seeking REIT exposure in the Asia-Pacific should recognise that sector-specific REITs had more prominent roles in post-GFC mixed-asset portfolios compared with their pre-GFC performance.

Table 5-28: Asia-Pacific sector-specific REIT asset allocation summary: domestic

	Sector-specific REITs	Diversified REITs	Stocks	Bonds
Panel A: Whole period				
Japan	57.9%	0.0%	0.2%	41.8%
Australia	40.2%	0.0%	32.9%	27.0%
Singapore	38.4%	28.5%	0.0%	33.0%
Panel B: Pre-GFC				
Japan	15.5%	0.0%	27.1%	57.3%
Australia	12.4%	0.0%	52.2%	35.3%
Singapore	33.9%	0.0%	40.8%	25.3%
Panel C: Post-GFC				
Japan	60.6%	0.0%	0.1%	39.2%
Australia	71.1%	0.0%	0.0%	28.9%
Singapore	40.9%	28.8%	0.0%	30.3%

5.6 SUMMARY OF CHAPTER

Overall, this chapter has demonstrated the stronger risk-adjusted performance, lower correlations with stocks and an added-value and strategic role in domestic mixed-asset portfolios for different property types of Asia-Pacific REITs compared with diversified REITs from July 2006 to December 2018. These validate the existence of REIT specialisation value in the Asia-Pacific over the study period, by comparing different property types of REITs with diversified REITs for the first time. The sub-period results reinforce the assertion of REIT specialisation value in the Asia-Pacific region. On top of REIT specialisation value, the sub-period analysis has revealed the changing nature of the performance of sector-specific REITs within domestic investment frameworks. The differential portfolio allocations for sector-specific REITs in each of the three markets can be elucidated by their distinct risk-adjusted performance and correlations with diversified REITs and the mainstream asset classes in each of the three markets. This highlights the importance of a detailed analysis of each REIT market in providing a fuller understanding of sector-specific REITs.

In this chapter, the analyses have been undertaken within a local investment framework. The next chapter will extend these analyses further, in order to highlight the performance and roles of sector-specific REITs in multi-asset portfolios in regional and international investment strategies.

CHAPTER 6
THE SIGNIFICANCE AND PERFORMANCE OF ASIA-PACIFIC-BASED SECTOR-SPECIFIC REITS IN REGIONAL AND GLOBAL MIXED-ASSET PORTFOLIOS

Chapter 6 examines the risk-return performance and added-value benefits of sector-specific REITs in regional and global mixed-asset portfolios, which comprises Asia-Pacific-based sector-specific REITs and stocks at the regional and global levels, as well as composite REITs in the USA and Europe. Risk-adjusted performance, portfolio diversification benefits and optimal asset allocations are assessed for the regional and global investment contexts. The results of this chapter were externally validated by the study of Lin et al. (2020), in which the regional mixed-asset portfolio was used for the robustness check, in order to assess the investment performance of regional sector-specific REITs in the Asia-Pacific region.

6.1 INTRODUCTION

The previous chapter presented the role and significance of sector-specific REITs in domestic mixed-asset portfolios across various domestic jurisdictions in the Asia-Pacific region. This chapter extends these analyses to explore the risk-return performance (as measured by the return/risk ratio) of Asia-Pacific-based sector-specific REITs relative to stocks in regional and global investment contexts from July 2006 to December 2018 (RQ3). To assess the investment performance of different property types of REITs in regional and global investment strategies, aggregate regional REIT sub-sector indices in the Asia-Pacific are constructed and measured in US dollars to mitigate exchange fluctuations for international property investors and to maintain research consistency. These include Asia-Pacific-based office, retail, industrial, residential, specialty and diversified REIT indices at the regional aggregative level. An optimal portfolio was employed to assess the role of Asia-Pacific-based sector-specific REITs in the regional and global mixed-asset investment frameworks, comprising comparable and equivalent regional and global assets. In a regional investment strategy, regional stocks were included as the benchmark proxy. In a global investment strategy, inter-REIT strategies across the Asia-Pacific, USA and Europe are explored. However, the regional and global bonds were not included in either regional or global investment contexts, since the researcher did not have sufficient access to regional and global bond series. The sub-period analysis was utilised to capture the dynamics of Asia-Pacific-based sector-specific REITs in regional and global investment contexts, in order to underpin the existence of REIT specialisation value in the Asia-Pacific region.

In this chapter, Section 6.2 and Section 6.3 explore the investment performance of Asia-Pacific-based sector-specific REITs in regional and international mixed-asset portfolios respectively. Section 6.4 summarises the key findings of this chapter and offers concluding comments.

6.2 ASIA-PACIFIC-BASED SECTOR-SPECIFIC REITs IN REGIONAL MIXED-ASSET INVESTMENT STRATEGIES

6.2.1 Risk-adjusted Performance Analysis

Table 6-1 presents the risk-adjusted performance for Asia-Pacific-based sector-specific and diversified REITs, as well as Asia-Pacific stocks, from July 2006 to December 2018. In terms of annual returns, specialty REITs (14.05% p.a.) delivered returns almost four times higher than regional stocks (3.90% p.a.) and other regional sector-specific and diversified REITs (−2.27% p.a.). It was followed by industrial (9.06% p.a.), office (3.72% p.a.), retail (2.36% p.a.) and residential REITs (−5.73% p.a.). In other words, there are only three regional sector-specific REITs superior to regional stocks – namely, regional specialty, industrial and office REITs. The annual risk levels of all regional sector-specific REITs (average 31.49%) were higher than regional stocks (16.80%). The poorest annual returns by regional residential REITs was paired with a substantially higher risk level of 46.18%. It was riskier than for regional office (35.71%), diversified (34.77%), specialty (29.57%), industrial (24.93%) and retail REITs (17.76%).

The strong annual returns coupled with comparatively low annual risk for specialty (the return/risk ratio = 0.48) and industrial REITs (0.36) positioned these two assets in the top two risk-adjusted performers, outpacing regional stocks (0.23), which is in third place in the risk-adjusted return ranking. In contrast, the least annual returns and the highest annual risk level adversely affected the risk-adjusted performance of regional residential REITs (−0.12), placing it last in the ranking, slightly below regional diversified (−0.07), office

(0.10) and retail REITs (0.13). These four assets clearly underperformed regional stocks on a risk-adjusted return basis, due to their mediocre annual returns and riskier attributes.

Figure 6-1 plots the risk-return profile of Asia-Pacific-based sector-specific and diversified REITs, as well as regional stocks based on the results of the above risk-adjusted return analysis. Regional specialty, industrial REITs and stocks are located on the superior upper-left quadrant of the scatter diagram. This illustrates that these three assets can produce higher investment returns without exposing investors to a high level of variance. On the other hand, office REITs was characterised the high-return/high-risk profiles over the full study period.

Table 6-1: Asia-Pacific-based sector-specific REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
REITs				
Diversified	−2.27	34.77	−0.07	6
Office	3.72	35.71	0.10	5
Retail	2.36	17.76	0.13	4
Industrial	9.06	24.93	0.36	2
Residential	−5.73	46.18	−0.12	7
Specialty	14.05	29.57	0.48	1
Asia-Pacific Stocks	3.90	16.80	0.23	3

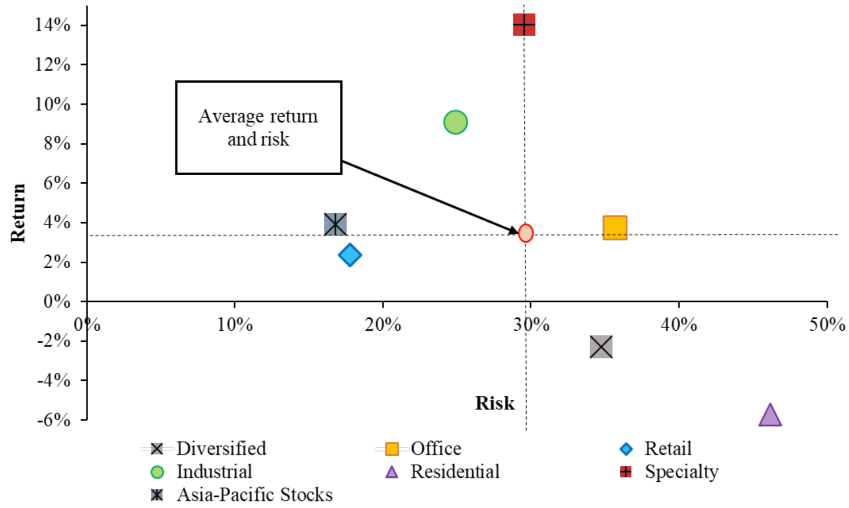
Note: *US dollars

Notably, the other three regional sector-specific REITs are positioned below the average annual return dotted line. Specifically, regional retail REITs is positioned on the low-return/low-risk quadrant. It is not unexpected to see retail REITs as a listed property investment vehicle, which traditionally featured low-return/low-risk attributes over the whole study period. Regional residential and diversified REITs are in the lower-right section of the scatter diagram, which indicates these two assets were unable to generate returns and expose investors to high volatility. This was caused by their mediocre annual returns and high annual risk levels over the entire study period, indicating the unfavourable risk-return trade-offs for these two assets. This is inconsistent with the expected risk-return profiles of a listed property investment vehicle, which is traditionally characterised by low-return/low-risk attributes.

6.2.2 Diversification Benefit Analysis

To assess the potential of portfolio diversification benefits of a regional sectoral REIT investment strategy, a correlation coefficient analysis of the data from July 2006 to December 2018 was conducted, as presented in **Table 6-2**. Utilising monthly total returns for Asia-Pacific-based sector-specific REITs, there was a comparatively strong linear relationship between one regional sector-specific REIT and the others (average $r = 0.63$) over the full study period.

Figure 6-1: Risk and return profiles of Asia-Pacific-based sector-specific REITs vs Asia-Pacific stocks: July 2006–December 2018



Generally, investors could receive better portfolio diversification benefits by adding regional stocks and sector-specific REITs (average $r = 0.72$), rather than including regional stocks and diversified REITs ($r = 0.74$). Specifically, larger portfolio diversification benefits could be obtained by including regional industrial REITs and stocks ($r = 0.67$) rather than regional specialty ($r = 0.72$), residential ($r = 0.72$), office ($r = 0.74$) and retail REITs ($r = 0.75$). In terms of an inter-property investment strategy, diversification within each property type of regional REITs and diversified REITs (average $r = 0.69$) was not desirable, compared with diversification within various property types of regional REITs (average $r = 0.63$). This is due to that a diversified REIT portfolio comprises multiple property sectors. This confirms that Asia-Pacific-based sector-specific REITs delivered larger portfolio diversification benefits than regional diversified REITs. The analysis indicates that a sectoral REIT investment strategy could provide greater diversification benefits for property investors compared with an inter-REIT investment strategy over the entire study period.

Table 6-2: Asia-Pacific-based sector-specific REIT correlations analysis: July 2006–December 2018

	AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty
AP Stocks	1.00						
Diversified	0.74*	1.00					
Office	0.74*	0.82*	1.00				
Retail	0.75*	0.79*	0.79*	1.00			
Industrial	0.67*	0.56	0.55*	0.61*	1.00		
Residential	0.72*	0.68*	0.61*	0.66*	0.63	1.00	
Specialty	0.72*	0.58	0.57*	0.62*	0.67*	0.62	1.00

Note: *Significant correlation (p<5%)

6.2.3 Mixed-asset Portfolio Analysis

Table 6-3 lists the portfolio compositions of efficient portfolios constructed using the mean-variance optimisation based on Asia-Pacific-based sector-specific REITs and regional stocks from July 2006 to December 2018. The expected portfolio returns and risk level for various optimised portfolios are highlighted in **Figure 6-2**, presenting the contributions of regional sector-specific REITs towards portfolio structures, relative to the risk level. At the lowest end, the portfolio allocations were mainly taken up by regional stocks (61.1%) and retail REITs (38.9%). At this level, the return on the optimised portfolio was 3.30% p.a., corresponding to an annual risk of 9.31%. At the middle point, the optimal portfolio delivered a portfolio return and risk of 10.26% p.a. and 13.19%, respectively. Under this scenario, the portfolio allocations comprised 47.6% regional specialty REITs, 29.7% regional industrial REITs and 22.7% regional stocks. At the highest point of the risk-return range, regional specialty REITs reached a maximum level of 100%, contributing a portfolio return and risk of 14.05% p.a. and 17.07%, respectively. However, there was no role for regional stocks and diversified REITs in the entire risk-return scale.

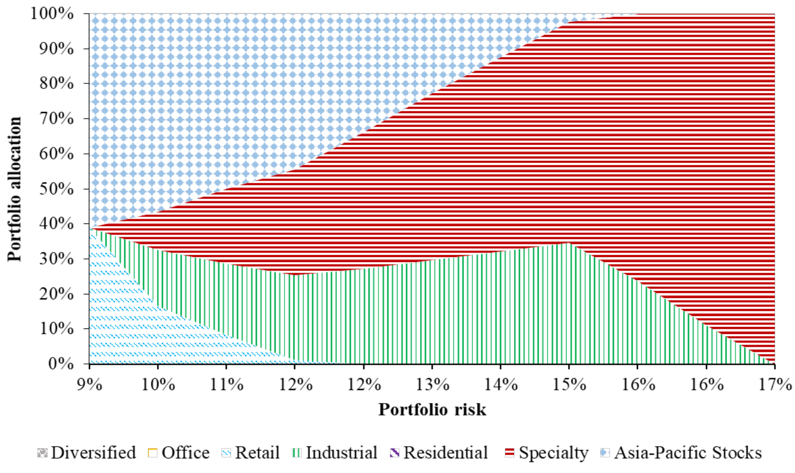
On average, regional portfolio efficiency could be achieved by allocating 48.4% specialty REITs, 25.8% stocks, 19.9% industrial REITs and 5.9% retail REITs. This shows that regional sector-specific REITs (average allocation = 74.2%) played a major role compared to regional diversified REITs (0.0%) and stocks (25.8%). Regional specialty

REITs dominated across the whole risk-return scale, displacing regional stocks and industrial and retail REITs when the risk level surged. It was situated in the higher end of the risk-return range as a high-return/high-risk investment asset. On the other hand, regional stocks was primarily present in the lower end of the risk-return scale. Regional industrial REITs was found across the broad risk-return range, overshadowing regional retail REITs in the lower end of the risk-return scale and complemented by regional specialty REITs in the higher end of the risk-return band. Regional retail REITs was located at the start of the risk-return spectrum.

Table 6-3: Asia-Pacific-based sector-specific REIT asset allocation: July 2006–December 2018

AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
61.1%	0.0%	0.0%	38.9%	0.0%	0.0%	0.0%	3.30%	9.31%
56.6%	0.0%	0.0%	16.6%	16.0%	0.0%	10.8%	5.57%	10.08%
50.0%	0.0%	0.0%	8.3%	20.4%	0.0%	21.3%	6.99%	10.86%
44.5%	0.0%	0.0%	1.2%	24.2%	0.0%	30.2%	8.19%	11.64%
33.7%	0.0%	0.0%	0.0%	27.1%	0.0%	39.1%	9.27%	12.41%
22.7%	0.0%	0.0%	0.0%	29.7%	0.0%	47.6%	10.26%	13.19%
12.3%	0.0%	0.0%	0.0%	32.2%	0.0%	55.4%	11.19%	13.97%
2.5%	0.0%	0.0%	0.0%	34.6%	0.0%	63.0%	12.08%	14.74%
0.0%	0.0%	0.0%	0.0%	23.7%	0.0%	76.3%	12.87%	15.52%
0.0%	0.0%	0.0%	0.0%	11.0%	0.0%	89.0%	13.50%	16.30%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	14.05%	17.07%

Figure 6-2: Asia-Pacific-based sector-specific REIT asset allocation diagram: July 2006–December 2018



6.2.4 Sub-period Analysis

The empirical results of the performance analysis for Asia-Pacific-based sector-specific REITs over two sub-periods – the pre-GFC (Panel A) and post-GFC (Panel B) timeframes – are displayed in **Table 6-4**. Prior to the GFC, all regional sector-specific (57.35% p.a.) and diversified REITs (44.40% p.a.) delivered higher average annual returns than regional stocks (27.28% p.a.). In addition, regional specialty (145.14% p.a.) and industrial REITs (45.03% p.a.) were the only two sector-specific REITs superior to regional diversified REITs, while the other three regional sector-specific REITs were inferior to regional diversified REITs, including regional office (34.35% p.a.), residential (32.90% p.a.) and retail REITs (29.32% p.a.). Interestingly, regional diversified REITs (21.87%) were riskier than most sector-specific REITs, namely regional retail (12.66%), industrial (21.37%) and office REITs (21.49%). The only two exceptions were regional specialty (27.91%) and residential REITs (24.29%). Overall, regional sector-specific REITs were riskier than regional stocks (7.79%). In terms of risk-adjusted returns, regional specialty REITs (return/risk ratio = 5.20) was the best performer on a risk-return trade-off basis. It was followed by the other regional sector-specific and diversified REITs (2.03) and regional stocks (3.50). These regional sector-specific REITs were regional retail (2.32), industrial (2.11), office (1.60) and residential REITs (1.35).

Post the GFC, most regional sector-specific REITs provided stronger annual returns than regional diversified REITs (5.87% p.a.) and stocks (5.74% p.a.), except for regional retail (4.81% p.a.) and residential REITs (1.42% p.a.). These included regional office (14.31% p.a.), industrial (10.94% p.a.) and specialty REITs (9.85% p.a.). In terms of annual risk, all regional sector-specific REITs and diversified REITs were riskier than the regional stocks (13.67%). Regional residential (28.35%) and office REITs (25.82%) are the only two assets with higher risk than regional diversified REITs (24.93%). The other regional sector-specific REITs offered lower annual risk levels than regional diversified REITs, including regional retail (15.92%), industrial (18.12%) and specialty REITs (21.13%). On a risk-adjusted return basis, regional industrial REITs provided the best risk-return trade-offs (return/risk ratio = 0.60) among all assets, outperforming regional office (0.55), specialty (0.47), retail (0.30) and residential REITs (0.05). Importantly, most regional sector-specific REITs were superior to regional diversified REITs (0.24), except for regional residential REITs. Compared with regional stocks (0.42), regional industrial, office and specialty REITs provided stronger risk-return trade-offs. However, regional retail and residential REITs were inferior to regional stocks.

Table 6-4: Asia-Pacific-based sector-specific REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Diversified	44.40	21.87	2.03	5
Office	34.35	21.49	1.60	6
Retail	29.32	12.66	2.32	3
Industrial	45.03	21.37	2.11	4
Residential	32.90	24.29	1.35	7
Specialty	145.14	27.91	5.20	1
Asia-Pacific Stocks	27.28	7.79	3.50	2
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Diversified	5.87	24.93	0.24	6
Office	14.31	25.82	0.55	2
Retail	4.81	15.92	0.30	5
Industrial	10.94	18.12	0.60	1
Residential	1.42	28.35	0.05	7
Specialty	9.85	21.13	0.47	3
Asia-Pacific Stocks	5.74	13.67	0.42	4

Note: *US dollars

Figure 6-3 presents risk-return profiles of Asia-Pacific-based sector-specific and diversified REITs over two sub-periods. Prior to the GFC (Panel A), regional specialty REITs is positioned in the normal upper-right quadrant of the scatter diagram. This implies this asset offered higher investment performance with a high level of volatility. Most of the other regional sector-specific REITs are found in the low-return/high-risk quadrant, namely regional industrial, diversified, office and residential REITs. Regional retail REITs and stocks are in the low-return/low-risk quadrant of the scatter diagram. This indicates these two assets exposed investors to a low risk level, with lesser annual returns.

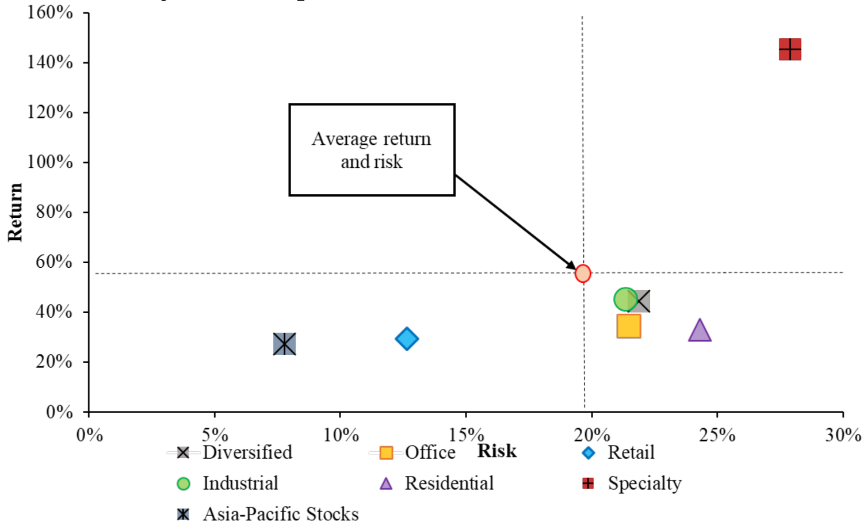
Post the GFC (Panel B), regional industrial and specialty REITs show their footprints in the superior upper-left quadrant of the scatter diagram. This indicates these two assets posted higher investment returns with a low level of volatility. Regional office REITs is positioned in the normal high-return/high-risk quadrant of the scatter diagram. On the other hand, regional retail and stocks maintain their pre-GFC positions in the lower-right quadrant of the scatter diagram. In addition, regional diversified and residential REITs keep their places in the lower-right quadrant of the scatter diagram. This suggests that these two assets failed to offer greater investment returns but exposed investors to a high level of variance. With higher risk-return trade-offs, most regional sector-specific REITs offered higher volatility to investors over the two sub-periods. The only exceptions are regional specialty REITs over both sub-periods and industrial REITs in the post-GFC context. This is inconsistent with the traditional low-return/low-risk attributes for the listed property investment asset.

The inter-asset correlation matrix between Asia-Pacific-based sector-specific REITs and regional stocks is reported in **Table 6-5**. Prior to the GFC (Panel A), the most interesting observation is that regional stocks were weakly correlated with regional office ($r = 0.38$) and specialty REITs ($r = 0.37$). Other regional sector-specific REITs were strongly correlated with regional stocks, including regional residential ($r = 0.56$), retail ($r = 0.64$), diversified ($r = 0.74$) and industrial REITs ($r = 0.80$). These saw regional sector-specific REITs offering higher portfolio diversifications over regional stocks than did regional diversified REITs. The exception is regional industrial REITs. In terms of an inter-property investment strategy, diversification within different property types of regional REITs and diversified REITs (average $r = 0.62$) was not desirable compared with diversification within various property types of regional REITs (average $r = 0.40$).

Post the GFC (Panel B), the correlation coefficients of regional stocks and sector-specific REITs (average $r = 0.64$) increased compared with their pre-GFC levels. Specifically, regional industrial REITs ($r = 0.56$) provided the strongest diversification benefits with regional stocks of all regional REIT sub-sectors. It was followed by regional diversified ($r = 0.64$), residential ($r = 0.65$), office ($r = 0.66$), specialty ($r = 0.67$) and retail REITs ($r = 0.68$). These show that most regional sector-specific REITs offered lesser diversification benefits with regional stocks than did regional diversified REITs, except for regional industrial REITs. Diversification within each property type of regional REITs and diversified REITs (average $r = 0.67$) was less desirable compared than diversification within different property types of regional REITs (average $r = 0.63$). However, the inclusion of regional industrial REITs could provide comparatively attractive portfolio diversification benefits for investors, since the average correlation coefficient of regional industrial REITs with the other assets was 0.56. It is noteworthy that diversifications between various property types of regional REITs and stocks vary over time. Nevertheless, the inter-asset correlations of regional sector-specific and diversified REITs had a distinct pattern over the two sub-periods.

Figure 6-3: Risk and return profiles of Asia-Pacific-based sector-specific REITs vs Asia-Pacific stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

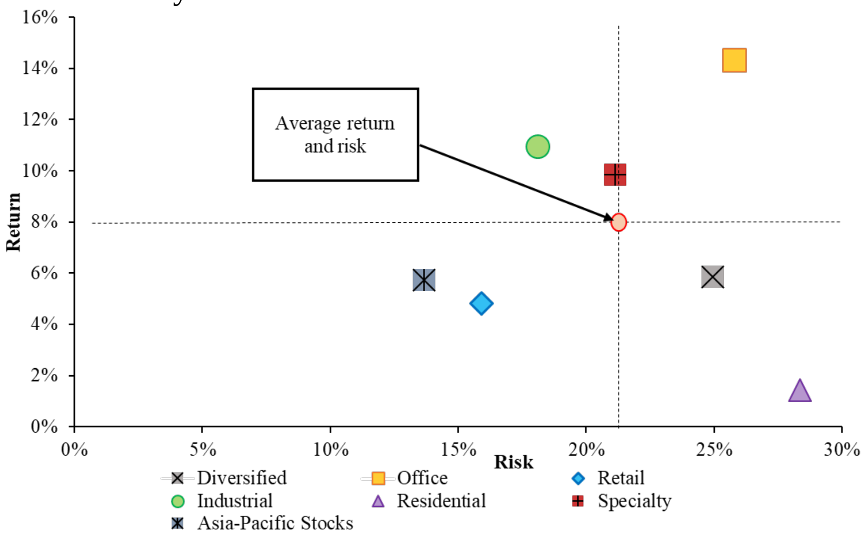


Table 6-5: Asia-Pacific-based sector-specific REIT sub-period correlations analysis

Panel A: Pre-GFC: July 2006–September 2007							
	AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty
AP Stocks	1.00						
Diversified	0.74*	1.00					
Office	0.38*	0.52*	1.00				
Retail	0.64*	0.92*	0.48*	1.00			
Industrial	0.80*	0.80*	0.58*	0.69*	1.00		
Residential	0.56*	0.52*	0.19*	0.58*	0.40*	1.00	
Specialty	0.37*	0.35*	0.34*	0.21*	0.49*	0.06*	1.00
Panel B: Post-GFC: July 2009–December 2018							
	AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty
AP Stocks	1.00						
Diversified	0.64*	1.00					
Office	0.66*	0.86*	1.00				
Retail	0.68*	0.80*	0.78*	1.00			
Industrial	0.56*	0.51*	0.59*	0.57*	1.00		
Residential	0.65*	0.70*	0.74*	0.70*	0.54*	1.00	
Specialty	0.67*	0.49*	0.60*	0.62*	0.61*	0.57*	1.00

Note: *Significant correlation ($p<5\%$)

Table 6-6 and **Figure 6-4** depict various regional portfolio-mix scenarios and their corresponding expected returns and risk in the pre-GFC timeframe, with a special focus on assessing roles of different property types of Asia-Pacific-based REITs in the regional mixed-asset portfolio. The optimised portfolio posted minimum and maximum annualised returns of 27.28% p.a. and 145.14% p.a., respectively, with the risk level ranging from 4.50–16.11%. The set of 11 efficient portfolios registered an average return of 93.99% p.a., attached to a 10.30% risk level.

At the lowest end, the portfolio allocations were mainly occupied by regional stocks (100.0%). At this level, the portfolio returns were 27.28% p.a., with a portfolio risk level of 4.50%. At the highest point of the risk-return range, regional specialty REITs reached a maximum level of 100%, while the other regional sector-specific REITs, diversified REITs and stocks did not play any role. In brief, regional specialty REITs (average allocation = 56.4%) dominated the entire risk-return range, overshadowing the portfolio allocations of regional stocks (36.0%) and residential (4.0%) and retail REITs (3.6%) when the risk level soared. Regional stocks mainly figured in the lower end of the risk-return band, while regional residential and retail REITs played minor roles in the higher end of the risk-return scale. With the lowest risk-return trade-offs, regional residential REITs was weakly correlated with the other assets, as a strategic investment asset in the mixed-asset portfolio. As such, regional residential REITs had some role in the optimal mixed-asset portfolio. With the lowest annual risk level, retail REITs was embedded in the portfolio to moderate the portfolio risk. However, regional diversified, office and industrial REITs did not have any role across the entire risk-return spectrum.

Table 6-6: Asia-Pacific-based sector-specific REIT asset allocation: pre-GFC: July 2006–September 2007

AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.28%	4.50%
78.2%	0.0%	0.0%	1.7%	0.0%	0.0%	20.1%	51.04%	5.66%
64.7%	0.0%	0.0%	4.0%	0.0%	0.0%	31.3%	64.25%	6.82%
53.0%	0.0%	0.0%	5.9%	0.0%	0.1%	41.0%	75.74%	7.98%
41.5%	0.0%	0.0%	6.0%	0.0%	2.6%	50.0%	86.50%	9.14%
30.4%	0.0%	0.0%	6.0%	0.0%	4.9%	58.7%	96.87%	10.30%
19.7%	0.0%	0.0%	6.0%	0.0%	7.1%	67.2%	107.00%	11.47%
9.0%	0.0%	0.0%	6.0%	0.0%	9.4%	75.5%	116.96%	12.63%
0.0%	0.0%	0.0%	4.7%	0.0%	11.5%	83.8%	126.80%	13.79%
0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	92.2%	136.33%	14.95%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	145.14%	16.11%

Figure 6-4: Asia-Pacific-based sector-specific REIT asset allocation diagram: pre-GFC: July 2006–September 2007

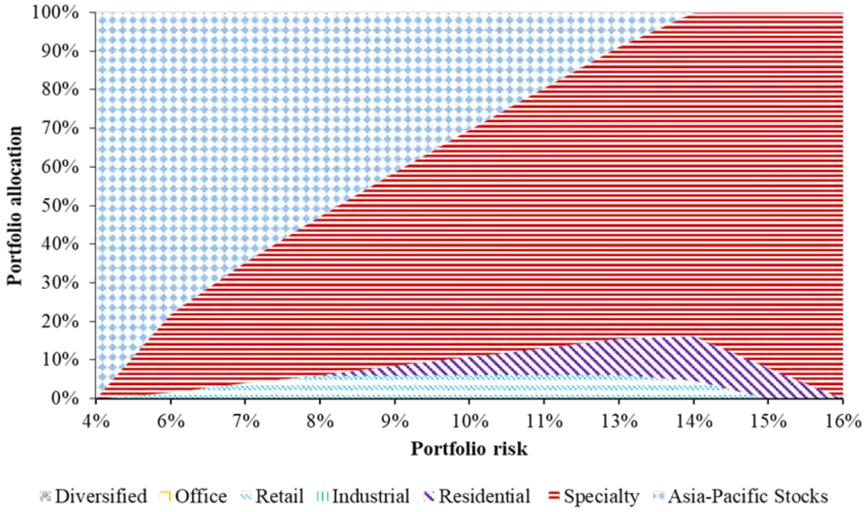


Table 6-7 and **Figure 6-5** portray various regional portfolio-mix scenarios and their corresponding expected returns and risk in the post-GFC timeframe. Compared with the pre-GFC performance, the post-GFC optimised portfolio featured a lesser role for regional stocks (an average allocation = 13.9%) but more roles for regional sector-specific REITs (86.1%). The post-GFC regional portfolio offered an average return that was much lower (11.71% p.a. versus 93.99% p.a.) and an average portfolio risk that was 94 base points higher (11.24% p.a. versus 10.30% p.a.) than its pre-GFC level. It offered minimum and maximum annualised returns of 6.32% p.a. and 14.31% p.a., respectively, with the risk ranging from 7.57 to 14.91%.

At the lowest point of the risk-return range, regional stocks (64.7%) comprised more than half of the portfolio, while regional retail (20.4%) and industrial REITs (14.9%) shared the rest of the portfolio allocations. At the highest end of the risk-return range, regional office REITs achieved a maximum level at 100%, while the other regional sector-specific REITs and stocks did not play any role. In short, the average portfolio compositions comprised 48.2% regional office REITs, 34.5% regional industrial REITs, 13.9% regional stocks, 1.9% regional retail REITs and 1.6% regional specialty REITs. Regional office REITs played a prominent role across the broad risk-return band, overshadowing the portfolio allocations of regional industrial REITs, stocks, retail and specialty REITs when the risk level surged. Regional industrial REITs featured across the broad risk-return scale, mainly presenting at the mid-point of the risk-return range. In addition, regional stocks was present in the lower end of the risk-return scale. Regional diversified REITs did not play any role across the entire risk-return scale. In brief, regional sector-specific REITs played a more important role than regional diversified REITs and stocks within the regional multi-asset portfolios over two sub-periods, particularly in the post-GFC context.

Figure 6-6 compares regional mixed-asset portfolio efficient frontiers across the pre- and post-GFC timeframes. As shown in the scatter diagram, the pre-GFC regional mixed-asset portfolio efficient frontier was longer and deeper than the post-GFC curve at each point of the risk-return spectrum. This implies that the pre-GFC portfolio produced higher investment returns attached to a lower risk level. The pre-GFC efficient frontier spanned a wider range of returns, from 27.28% p.a. to 145.14% p.a., and risk levels from 4.50% to 16.11%. On the other hand, the post-GFC efficient frontier figured a narrower range of returns, from 6.32% p.a. to 14.31% p.a., and risk levels from 7.57% to 14.91%.

Table 6-7: Asia-Pacific-based sector-specific REIT asset allocation: post-GFC: July 2009–December 2018

AP Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
64.7%	0.0%	0.0%	20.4%	14.9%	0.0%	0.0%	6.32%	7.57%
46.5%	0.0%	6.4%	0.0%	46.3%	0.0%	0.8%	8.73%	8.30%
28.2%	0.0%	15.3%	0.0%	52.9%	0.0%	3.6%	9.95%	9.03%
13.0%	0.0%	22.8%	0.0%	58.3%	0.0%	5.9%	10.97%	9.77%
0.0%	0.0%	30.3%	0.0%	62.8%	0.0%	6.9%	11.89%	10.50%
0.0%	0.0%	47.9%	0.0%	52.1%	0.0%	0.0%	12.55%	11.24%
0.0%	0.0%	61.3%	0.0%	38.7%	0.0%	0.0%	13.01%	11.97%
0.0%	0.0%	72.4%	0.0%	27.6%	0.0%	0.0%	13.38%	12.71%
0.0%	0.0%	82.3%	0.0%	17.7%	0.0%	0.0%	13.71%	13.44%
0.0%	0.0%	91.4%	0.0%	8.6%	0.0%	0.0%	14.02%	14.17%
0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	14.31%	14.91%

Figure 6-5: Asia-Pacific-based sector-specific REIT asset allocation diagram: post-GFC: July 2009–December 2018

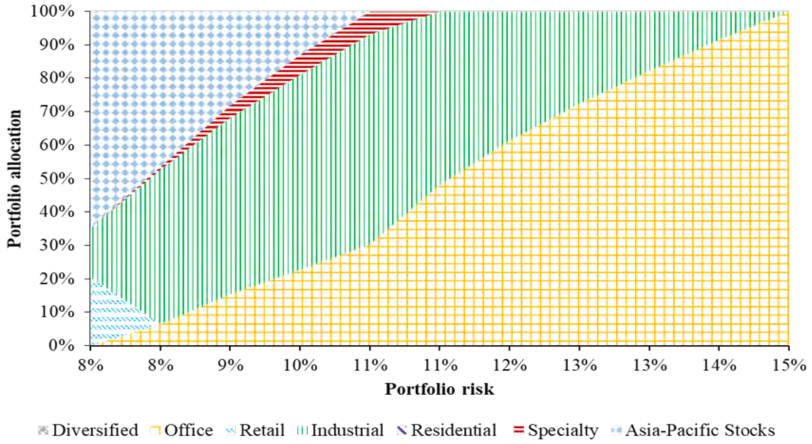
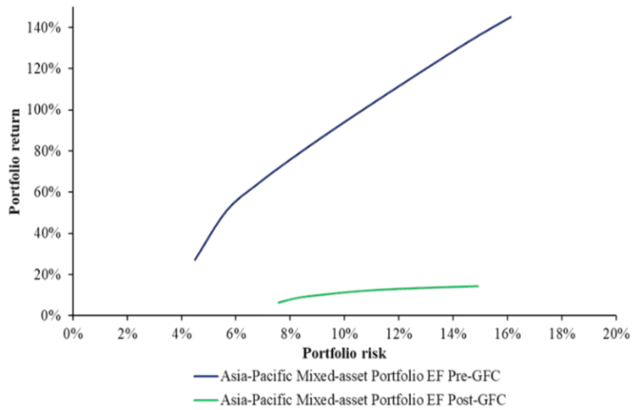


Figure 6-6: Asia-Pacific-based mixed-asset portfolio efficient frontiers: Pre-GFC vs post-GFC



6.2.5 Summary of Findings

Table 6-8 summarises the empirical results of Asia-Pacific-based sector-specific REITs in the regional framework from July 2006 to December 2018. As shown in Panel A, most regional sector-specific REITs outperformed regional diversified REITs on a risk-adjusted return basis, owing to their higher average annual returns and comparatively lower risk levels over the full study period. These included regional office, retail, industrial and specialty REITs. The only exception was regional residential REITs. Compared with regional stocks, regional industrial and specialty REITs offered higher risk-adjusted returns, while regional office, retail and residential REITs were inferior to regional stocks, due to their higher annual volatility. The stronger risk-adjusted performance of regional sector-specific REITs compared with regional diversified REITs was strengthened by the sub-period analysis. In general, few regional sector-specific REITs outperformed regional stocks in the pre-GFC investment context, while most regional sector-specific REITs were superior to regional stocks in the post-GFC period.

Most regional sector-specific REITs presented stronger diversification benefits with regional stocks than did regional diversified REITs over the full sample period, as presented in Panel B. Regional retail REITs was the only exception. The sub-period results show that most regional sector-specific REIT were superior to their diversified counterparts prior to the GFC, but were inferior to regional diversified REITs post the GFC. The only exception was regional industrial REITs over two sub-periods. A sectoral REIT diversification strategy (average $r = 0.63$) offered more attractive portfolio diversification benefits than an inter-REIT diversification strategy (average $r = 0.69$) over the full sample period, including the pre-GFC (average $r = 0.40$; 0.62) and post-GFC periods (average $r = 0.63$; 0.67).

As displayed in Panel C, different property types of regional REITs played a more important role in the regional multi-asset portfolios over the entire study period, including the two sub-periods. In particular, regional sector-specific REITs enlarged their roles in the optimal mixed-asset portfolio in the post-GFC context, while they played a lesser role in portfolio composition in the pre-GFC context. Meanwhile, regional stocks had some portfolio allocations, while regional diversified REITs did not play any role in the optimal portfolio compositions.

Table 6-8: Asia-Pacific-based sector-specific REIT performance summary: regional

Panel A: Return, risk and risk-adjusted return performance

Whole period	Asset	Return	Risk	Risk-adjusted return
1 versus	6	✔	✔	✔
	7	✘	✘	✘
2 versus	6	✔	✔	✔
	7	✘	✘	✘
3 versus	6	✔	✔	✔
	7	✔	✘	✔
4 versus	6	✘	✘	✘
	7	✘	✘	✘
5 versus	6	✔	✔	✔
	7	✔	✘	✔
Pre-GFC				
1 versus	6	✘	✔	✘
	7	✔	✘	✘
2 versus	6	✘	✔	✔
	7	✔	✘	✘
3 versus	6	✔	✔	✔
	7	✔	✘	✘
4 versus	6	✘	✘	✘
	7	✔	✘	✘
5 versus	6	✔	✘	✔
	7	✔	✘	✔
Post-GFC				
1 versus	6	✔	✘	✔
	7	✔	✘	✔
2 versus	6	✘	✔	✔
	7	✘	✘	✘
3 versus	6	✔	✔	✔
	7	✔	✘	✔
4 versus	6	✘	✘	✘
	7	✘	✘	✘
5 versus	6	✔	✔	✔
	7	✔	✘	✔

Panel B: Portfolio Diversification benefits

Whole period	1-7	2-7	3-7	4-7	5-7	6-7	(1+2+3+4+5)-6
Average r =	0.74	0.75	0.67	0.72	0.72	0.74	0.69
Pre-GFC							
Average r =	0.38	0.64	0.80	0.56	0.37	0.74	0.62
Post-GFC							
Average r =	0.66	0.68	0.56	0.65	0.67	0.64	0.67

Panel C: Asset allocation (%)

Whole period	1	2	3	4	5	6	7
Average allocation	0.0	5.9	19.9	0.0	48.4	0.0	25.8
Pre-GFC							
Average allocation	0.0	3.7	0.0	4.0	56.4	0.0	36.0
Post-GFC							
Average allocation	48.2	1.9	34.5	0.0	1.6	0.0	13.9

Note: 1 = office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty, 6 = diversified, 7 = AP stocks

6.3 ASIA-PACIFIC-BASED SECTOR-SPECIFIC REITs IN GLOBAL MIXED-ASSET INVESTMENT STRATEGIES

6.3.1 Risk-adjusted Performance Analysis

The risk-adjusted performance for Asia-Pacific-based sector-specific REITs and global stocks from July 2006 to December 2018 is documented in **Table 6-9**. In terms of annualised returns, regional specialty (14.05% p.a.) and industrial REITs (9.06% p.a.) were superior to global stocks (5.43% p.a.) and US-REITs (5.39% p.a.), while regional office (3.72% p.a.), retail (2.36% p.a.), diversified (−2.27% p.a.) and residential REITs (−5.73% p.a.) underperformed these two assets. Compared with EU-REITs (−1.05% p.a.), most regional REITs offered higher annual returns, except for regional residential and diversified REITs. The annual risk levels for all regional sector-specific REITs were higher than global stocks (annual risk = 15.85%), including regional retail (17.76%), industrial (24.93%), specialty (29.57%), office (35.71%), residential REITs (46.18%) and diversified REITs (34.77%). Compared with US- (22.15%) and EU-REITs (23.46%), most regional sector-specific and diversified REITs were more volatile, except for regional retail REITs. Regional diversified and residential REITs exposed investors to comparatively higher risk levels, with poor annualised returns. In terms of risk-adjusted returns, regional specialty (the return/risk ratio = 0.48) and industrial REITs (0.36) were the only two regional sector-specific REITs superior to global stocks (0.34) and US-REITs (0.24), while regional retail (0.13), office (0.10), diversified (−0.07) and residential REITs (−0.12) were inferior to global stocks and US-REITs. Compared with EU-REITs, most sector-specific REITs offered stronger risk-adjusted returns, except for regional diversified and residential REITs.

Figure 6-7 plots risk-return profiles of different property types of Asia-Pacific-based REITs, diversified REITs, US-REITs, EU-REITs and global stocks from July 2006 to December 2018. As evident from the above performance analysis, the superior risk-return trade-off for regional industrial REITs sees it feature in the superior upper-left quadrant of the scatter diagram, with global stocks and US-REITs. This confirms that these three assets can offer higher investment returns attached to a lower risk level. In other words, they had a higher risk-return trade-offs level than the other regional sector-specific and diversified REITs.

Table 6-9: Performance analysis*: Asia-Pacific-based sector-specific REITs vs global stocks, US- and EU-REITs: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
REITs				
Diversified	−2.27	34.77	−0.07	8
Office	3.72	35.71	0.10	6
Retail	2.36	17.76	0.13	5
Industrial	9.06	24.93	0.36	2
Residential	−5.73	46.18	−0.12	9
Specialty	14.05	29.57	0.48	1
US-REITs	5.39	22.15	0.24	4
EU-REITs	−1.05	23.46	−0.04	7
Global Stocks	5.43	15.85	0.34	3

Note: *US dollars

Regional specialty and office REITs are positioned in the upper right quadrant of the scatter diagram, associated with high-risk/high-return investments. Varying from the traditional listed property investment assets characterised by low-return/low-risk attributes, regional specialty and office REITs featured much higher volatility attributes over the entire study period. Regional retail REITs and EU-REITs are placed in the low-return/low-risk quadrant of the scatter diagram, which is consistent with the traditional risk-return profiles of listed property investment vehicles. Regional residential and diversified REITs had low-return/high-risk attributes and are situated in the lower-right quadrant of the scatter diagram, below the average return borderline. This suggests that regional residential and diversified REITs failed to deliver appealing returns but exposed investors to a high-risk level, being inferior to most regional sector-specific REITs, US- and EU-REITs and global stocks on a risk-return trade-offs basis.

6.3.2 Diversification Benefit Analysis

The inter-asset correlation matrix for Asia-Pacific-based sector-specific REITs, diversified REITs, global stocks, US-REITs and EU-REITs is shown in **Table 6-10**. Employing the monthly total returns for regional sector-specific REITs, the inter-asset portfolio diversification benefits between one regional sector-specific REITs and the others are unappealing for investors, evident by a strong average coefficient correlation of 0.63 over the entire sample period.

Additionally, there were comparatively strong linear relationships between global stocks and regional sector-specific REITs, namely regional industrial ($r = 0.63$), specialty ($r = 0.66$), residential ($r = 0.71$), office ($r = 0.76$) and retail REITs ($r = 0.76$). However, most regional sector-specific REITs delivered stronger diversification benefits with global stocks (average $r = 0.70$) than did diversified REITs ($r = 0.75$), except for regional office and retail REITs.

Similarly, regional specialty (r = 0.44), industrial (r = 0.52) and residential REITs (r = 0.58) delivered higher diversification benefits with US-REITs than did diversified REITs (r = 0.62). Regional office and retail REITs were the exceptions. In terms of portfolio diversification benefits with EU-REITs, regional industrial (r = 0.47), specialty (r = 0.58) and residential REITs (r = 0.58) outpaced diversified REITs (r = 0.59), while regional office (r = 0.61) and retail REITs (r = 0.64) were inferior to their diversified counterparts. In short, investors seeking to build a global mixed-asset portfolio would not obtain effective portfolio diversification benefits by combining global stocks and regional sector-specific REITs (average r = 0.70). In this case, they were better served by pairing global stocks with regional REIT sub-sectors over the entire study timeframe. However, regional industrial, specialty and residential REITs provided appealing diversification benefits with both US- and EU-REITs.

Figure 6-7: Risk and return profiles of Asia-Pacific-based sector-specific REITs vs global stocks, US- and EU-REITs: July 2006–December 2018

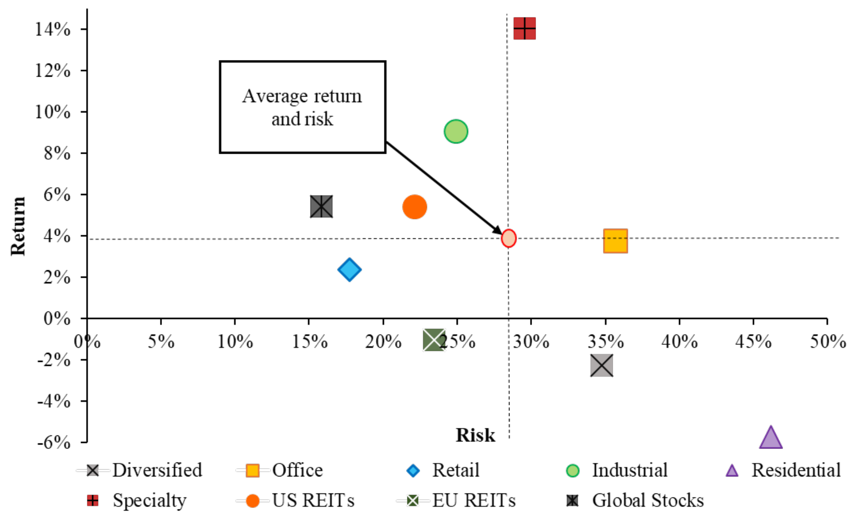


Table 6-10: Correlations analysis: Asia-Pacific-based REITs vs global stocks, US- and EU-REITs: July 2006–December 2018

	Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US-REITs	EU-REITs
Global Stocks	1.00								
Diversified	0.75	1.00							
Office	0.76*	0.82*	1.00						
Retail	0.76*	0.79*	0.79*	1.00					
Industrial	0.63*	0.56	0.55*	0.61*	1.00				
Residential	0.71	0.68*	0.61*	0.66*	0.63	1.00			
Specialty	0.66*	0.58	0.57*	0.62*	0.67*	0.62	1.00		
US-REITs	0.72	0.62*	0.62*	0.66*	0.52*	0.58	0.44	1.00	
EU-REITs	0.76	0.59*	0.61*	0.64*	0.47*	0.58*	0.58	0.72*	1.00

Note: *Significant correlation (p<5%)

Table 6-11: Global mixed-asset portfolio asset allocation: July 2006–December 2018

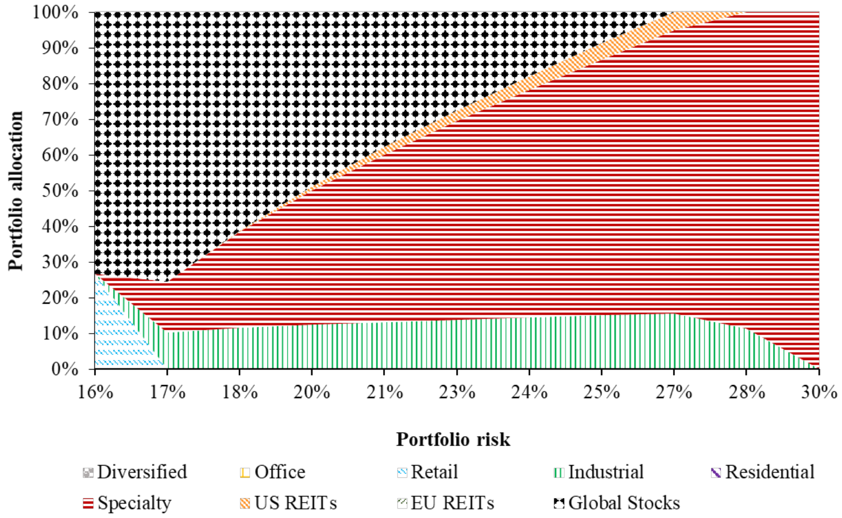
Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US-REITs	EU-REITs	Portfolio return	Portfolio risk
73.2%	0.0%	0.0%	26.8%	0.0%	0.0%	0.0%	0.0%	0.0%	4.60%	15.54%
75.6%	0.0%	0.0%	0.0%	10.4%	0.0%	14.0%	0.0%	0.0%	7.01%	16.94%
61.2%	0.0%	0.0%	0.0%	11.6%	0.0%	27.0%	0.2%	0.0%	8.18%	18.35%
48.7%	0.0%	0.0%	0.0%	12.4%	0.0%	37.6%	1.2%	0.0%	9.12%	19.75%
37.7%	0.0%	0.0%	0.0%	13.2%	0.0%	47.0%	2.2%	0.0%	9.96%	21.15%
27.5%	0.0%	0.0%	0.0%	13.8%	0.0%	55.7%	3.0%	0.0%	10.73%	22.56%
17.9%	0.0%	0.0%	0.0%	14.5%	0.0%	63.9%	3.8%	0.0%	11.46%	23.96%
8.7%	0.0%	0.0%	0.0%	15.1%	0.0%	71.7%	4.5%	0.0%	12.16%	25.36%
0.0%	0.0%	0.0%	0.0%	15.6%	0.0%	79.3%	5.1%	0.0%	12.83%	26.77%
0.0%	0.0%	0.0%	0.0%	11.5%	0.0%	88.5%	0.0%	0.0%	13.47%	28.17%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	14.05%	29.57%

6.3.3 Mixed-asset Portfolio Analysis

Table 6-11 and **Figure 6-8** report various global portfolio-mix scenarios and their corresponding expected returns and risk from July 2006 to December 2018, with an emphasis on the assessment of roles of Asia-Pacific-based sector-specific and diversified REITs in the global mixed-asset portfolio. Using monthly total returns of regional sector-specific REITs, diversified REITs, global stocks, US- and EU-REITs, the optimised portfolio expected portfolio returns varied from 4.60% to 14.05% p.a., with portfolio risk levels ranging from 15.54% to 29.57%. The set of 11 efficient portfolios registered an average return of 10.32% p.a., with a risk level of 22.56%.

At the lowest point, the portfolio allocations consisted of 73.2% global stocks and 26.8% regional retail REITs. In the middle, more than half of the portfolio comprised regional specialty REITs; global stocks fell to 27.5%, with 13.8% regional industrial REITs and 3.0% US-REITs. At this level, the optimal portfolio posted an average portfolio return and risk of 10.73% p.a. and 22.56%, respectively. At the highest end of the risk-return range, regional specialty REITs enlarged its portfolio allocation to a maximum level of 100%, while global stocks did not play any role. On average, portfolio efficiency could be achieved by allocating 53.1% regional specialty REITs, 31.9% global stocks, 10.7% regional industrial REITs, 2.4% regional retail REITs and 1.8% US-REITs. Regional specialty REITs dominated across the whole risk-return band, diminishing the portfolio compositions of global stocks, regional retail and US-REITs when the risk level soared, but co-existing with regional industrial REITs across the broad risk-return scale. Global stocks mainly showed its footprint at the lower end of the risk-return range, displacing regional retail REITs. Regional retail REITs only figured at the start of the risk-return scale. This clearly implies the strong risk-return trade-offs for regional specialty and industrial REITs, since they were embedded across the entire risk-return spectrum.

Figure 6-8: Global mixed-asset portfolio asset allocation diagram: July 2006–December 2018



6.3.4 Sub-period Analysis

The empirical results of risk-adjusted returns for Asia-Pacific-based sector-specific REITs, diversified REITs, global stocks, US- and EU-REITs over two sub-periods, namely the pre-GFC (Panel A) and post-GFC (Panel B) timeframes, are tabulated in **Table 6-12**. In the pre-GFC context, all regional sector-specific (57.35% p.a.) and diversified REITs (44.40% p.a.) outperformed global stocks (24.73% p.a.), US- (6.80% p.a.) and EU-REITs (9.48% p.a.) in terms of annualised returns. These included regional specialty (145.14% p.a.), industrial (45.03% p.a.), office (34.35% p.a.), residential (32.90% p.a.) and retail REITs (29.32% p.a.). The most interesting observation is that all regional sector-specific (average risk = 23.76%) and diversified REITs (21.87%) were riskier than global stocks, including regional specialty (27.91%), residential (24.29%), office (21.49%), industrial (21.37%) and retail REITs (12.66%). Most regional sector-specific REITs and diversified REITs were also riskier than US- (18.07%) and EU-REITs (18.21%), except for regional retail REITs. With the second-highest annualised returns, regional specialty REITs (return/risk ratio = 5.20) was the only regional REIT sub-sectors outshining global stocks (3.53), while the other regional sector-specific and diversified REITs (2.03) were inferior to global stocks, including regional retail (2.32), industrial (2.11), office (1.60) and residential REITs (1.35). Importantly, all regional sector-specific and diversified REITs offered better risk-return trade-offs than that US- (0.38) and EU-REITs (0.52).

In the post-GFC context, most regional sector-specific REITs offered higher annualised returns than global stocks (8.65% p.a.), including regional office (14.31% p.a.), industrial (10.94% p.a.) and specialty REITs (9.85% p.a.). On the other hand, regional diversified (5.87% p.a.), retail (4.81% p.a.) and residential REITs (1.42% p.a.) were inferior to global stocks. All regional sector-specific and diversified REITs underperformed US-REITs (13.39% p.a.) in terms of average annualised returns, but all outperformed EU-REITs (4.81%), except for regional residential REITs. The risk levels of all regional sector-specific REITs and diversified REITs (24.93%) were higher than global stocks (13.09%) and US-REITs (15.03%), such as regional residential (28.35%), office (25.82%), specialty (21.13%), industrial (18.12%) and retail REITs (15.92%). Regional retail and industrial REITs were less volatile than EU-REITs (21.02%), while most regional sector-specific REITs were riskier than EU-REITs.

Despite contributing superior annualised returns, regional sector-specific REITs and diversified REITs (0.24) failed to deliver better risk-return trade-offs than global stocks (0.66) and US-REITs (0.89), due to their comparatively higher annual risk levels. In particular, regional industrial, office and specialty REITs occupied third to the fifth places in the risk-adjusted return ranking, posting risk-return trade-offs (via the return/risk ratio) of 0.60, 0.55 and 0.47, respectively. For the other two regional sector-specific REITs, the lower annual returns and higher volatility of regional retail and residential REITs made them inferior to global stocks and US-REITs on a risk-adjusted return basis. However, all regional sector-specific and diversified REITs outperformed EU-REITs in terms of risk-return trade-offs, except for regional residential REITs.

Table 6-12: Sub-period performance analysis*: Asia-Pacific-based sector-specific REITs vs global stocks, US- and EU-REITs

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Diversified	44.40	21.87	2.03	5
Office	34.35	21.49	1.60	6
Retail	29.32	12.66	2.32	3
Industrial	45.03	21.37	2.11	4
Residential	32.90	24.29	1.35	7
Specialty	145.14	27.91	5.20	1
US-REITs	6.80	18.07	0.38	9
EU-REITs	9.48	18.21	0.52	8
Global Stocks	24.73	7.01	3.53	2
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Diversified	5.87	24.93	0.24	7
Office	14.31	25.82	0.55	4
Retail	4.81	15.92	0.30	6
Industrial	10.94	18.12	0.60	3
Residential	1.42	28.35	0.05	9
Specialty	9.85	21.13	0.47	5
US-REITs	13.39	15.03	0.89	1
EU-REITs	4.81	21.02	0.23	8
Global Stocks	8.65	13.09	0.66	2

Note: *US dollars

Figure 6-9 portrays risk-return profiles of Asia-Pacific-based sector-specific REITs, diversified REITs, global stocks, US- and EU-REITs based on the results of the earlier risk-adjusted return analysis over two sub-periods, the pre-GFC (Panel A) and post-GFC (Panel B) timeframes. Prior to the GFC, regional specialty, diversified and industrial REITs are the only three assets plotted in the normal upper-right quadrant of the scatter diagram, offering higher investment returns with a high level of standard deviation. As seen in the figure, regional specialty REITs had a higher risk-return trade-offs level than regional diversified and industrial REITs. In addition, regional residential and office REITs are found in the lower-right quadrant associated with the low-return/high-risk investments. This implies that these three assets exposed investors to a high level of volatility without generating sufficient investment returns. On the other side, global stocks, regional retail REITs, US- and EU-REITs are positioned in the lower-left quadrant of the scatter diagram associated with low-return/low-risk investments. This indicates these four assets featured the traditional risk-return profiles of listed property investment channels.

Post the GFC, regional industrial REITs is the only regional sector-specific REITs in the upper-right high-return/low-risk quadrant of the scatter diagram, co-existing with global stocks and US-REITs. This indicates that these three assets were characterised by a comparatively high level of risk-return trade-offs, without exposing investors to a high level of volatility. Regional office and specialty REITs are plotted in the normal upper-right quadrant of the scatter diagram associated with the high-return/high-risk investments. Conversely, regional residential, diversified and EU-REITs are placed in the lower-left quadrant associated with low-return/low-risk investments. This implies that these three assets failed to generate superior annual returns but increased the level of risk. Regional retail REITs maintain their pre-GFC place in the lower-left quadrant of the scatter diagram. This implies that regional retail REITs could be the most appropriate REIT sub-sector for conservative investors.

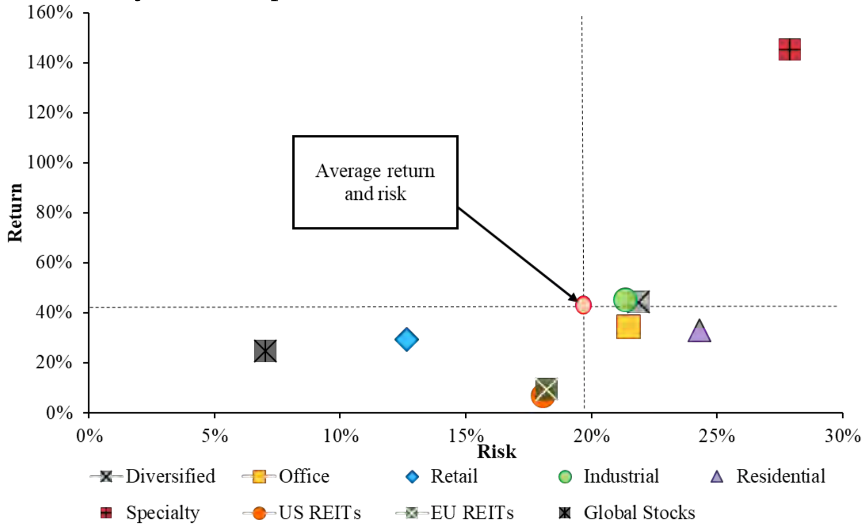
Table 6-13 reports the inter-asset correlation matrix between Asia-Pacific-based sector-specific REITs, diversified REITs, global stocks, US- and EU-REITs over two sub-periods, namely the pre-GFC (Panel A) and post-GFC (Panel B) timeframes. In the pre-GFC context, regional specialty ($r = 0.22$), residential ($r = 0.38$) and office REITs ($r = 0.58$) were weakly correlated with global stocks, while regional retail ($r = 0.73$), industrial ($r = 0.81$) and diversified REITs ($r = 0.82$) were strongly correlated with global stocks. Among regional sector-specific REITs, regional specialty REITs offered the strongest diversification benefits with global stocks and was the best portfolio diversifier. Regional specialty, residential and office REITs did not move closely with the global stock markets, suggesting that investors could receive greater portfolio diversification benefits by augmenting global stocks with these three assets. This shows that different property types of regional REITs provided stronger diversification benefits with global stocks than did regional diversified REITs. In contrast, different property types of regional sector-specific REITs were weakly correlated with both US- (average $r = 0.09$) and EU-REITs (average $r = 0.02$), providing higher diversification benefits with both US- and EU-REITs than did diversified REITs ($r = 0.36$; $r = 0.15$). This implies that investors seeking listed property portfolio diversifications in the international context could receive attractive portfolio diversification benefits by augmenting either US- or EU-REITs with Asia-Pacific-based sector-specific REITs. Diversification within regional sector-specific REITs and diversified REITs (average $r = 0.62$) was not desirable for investors, while diversification within different property types of regional REITs (average $r = 0.40$) was tempting for investors seeking portfolio diversification benefits in the Asia-Pacific region.

In the post-GFC context, regional industrial REITs ($r = 0.50$) replaced pre-GFC regional specialty REITs as the best portfolio diversifier with global stocks. It was followed by regional specialty ($r = 0.61$), residential ($r = 0.66$), diversified ($r = 0.66$), office ($r = 0.68$) and retail REITs ($r = 0.68$). This saw regional sector-specific and diversified REITs generally lose their portfolio diversification advantage over global stocks in the post-GFC context. The correlations with both US- and EU-REITs for all regional sector-specific and diversified REITs increased from the pre-GFC levels. Diversification within regional sector-specific REITs and diversified REITs (average r = 0.67) was not desirable compared with diversification within various property types of regional REITs (average $r = 0.63$). Both the post-GFC regional sectoral REIT and inter-REIT portfolio diversification strategies were less attractive compared to their pre-GFC performance. Importantly, diversifications between various property types of regional REITs and global stocks, and the inter-asset correlations varied over time.

Table 6-14 illustrates the portfolio compositions of efficient portfolios constructed using the mean-variance optimisation process for Asia-Pacific-based sector-specific REITs, diversified REITs, global stocks, US- and EU-REITs over the pre-GFC timeframe, with special attention on assessing the roles of different property types of regional REITs in the global mixed-asset investment portfolio, as well as the expected returns and risk levels for various optimised portfolios. **Figure 6-10** depicts the contributions of Asia-Pacific-based sector-specific REITs to global portfolio structures, relative to risk level. Prior to the GFC, the global portfolio expected returns of between 23.70% and 145.14% p.a., with portfolio risk levels ranging from 6.90% to 27.91% according to the risk-return level (from lowest to highest). In short, the pre-GFC global mixed-asset portfolio posted an average portfolio return and risk of 93.31% p.a. and 17.41%, respectively.

Figure 6-9: Risk and return profiles of Asia-Pacific-based sector-specific REITs vs global stocks, US- and EU-REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

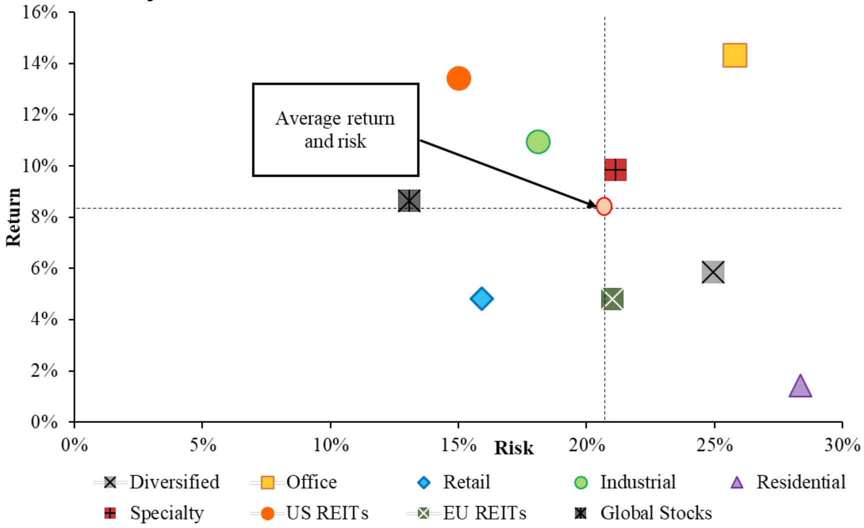


Table 6-13: Sub-period correlations analysis: Asia-Pacific-based sector-specific REITs vs global stocks, US- and EU-REITs

Panel A: Pre-GFC: July 2006–September 2007

	Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US-REITs	EU-REITs
Global Stocks	1.00								
Diversified	0.82	1.00							
Office	0.58*	0.52*	1.00						
Retail	0.73*	0.92*	0.48*	1.00					
Industrial	0.81*	0.80*	0.58*	0.69*	1.00				
Residential	0.38*	0.52*	0.19*	0.58*	0.40*	1.00			
Specialty	0.22*	0.35*	0.34*	0.21*	0.49*	0.06*	1.00		
US-REITs	0.51	0.36	0.01	0.44	0.14	-0.08	-0.10	1.00	
EU-REITs	0.21	0.15	-0.25	0.07	0.18	-0.23	0.32	0.40*	1.00

Panel B: Post-GFC: July 2009–December 2018

	Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US-REITs	EU-REITs
Global Stocks	1.00								
Diversified	0.66	1.00							
Office	0.68*	0.86*	1.00						
Retail	0.68*	0.80*	0.78*	1.00					
Industrial	0.50*	0.51*	0.59*	0.57*	1.00				
Residential	0.66*	0.70*	0.74*	0.70*	0.54*	1.00			
Specialty	0.61*	0.49*	0.60*	0.62*	0.61*	0.57*	1.00		
US-REITs	0.66*	0.67*	0.63*	0.70*	0.45*	0.50*	0.53*	1.00	
EU-REITs	0.76*	0.61*	0.61*	0.62*	0.34*	0.56*	0.60*	0.63*	1.00

Note: *Significant correlation (p<5%)

At the lowest end, the portfolio allocations comprised 93.3% global stocks and 6.7% EU-REITs. In the middle, half of the portfolio allocation went to regional specialty REITs, with 35.9% global stocks and 5% EU-REITs. At this level, the portfolio returns and risk of the mixed-asset portfolio were 96.38% p.a. and 17.41%, respectively. At the highest point, regional specialty REITs reached a maximum level of 100%, contributing portfolio returns and risk of 145.14% p.a. and 27.91%, respectively.

The total portfolio compositions of each risk-return level were generally halved by regional specialty REITs (an average allocation = 56.8%) and global stocks (38.8%), with a minor role for regional residential (3.9%) and EU-REITs (0.5%) at the lowest end of the risk-return band. Specifically, global stocks primarily showed its presence in the lower end of the risk-return range, but were displaced by regional specialty REITs when the risk level enhanced. Despite figuring across the whole risk-return scale, regional specialty REITs gradually enlarged its portfolio share when the risk level heightened. However, regional diversified REITs did not play any role across the entire risk-return range. This underpins the REIT specialisation value in the Asia-Pacific region.

Figure 6-10: Global mixed-asset portfolio asset allocation diagram: pre-GFC: July 2006–September 2007

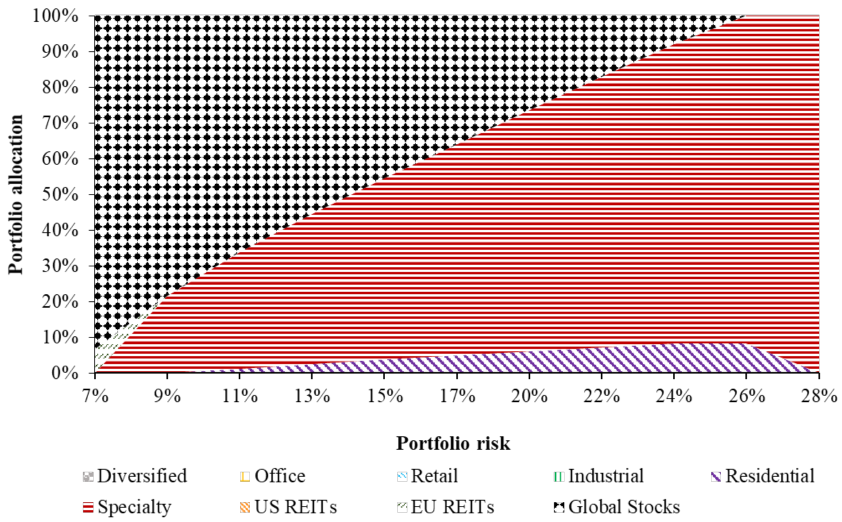


Table 6-14: Global mixed-asset portfolio asset allocation: pre-GFC: July 2006–September 2007

Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US-REITs	EU-REITs	Portfolio return	Portfolio risk
93.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%	23.70%	6.90%
78.3%	0.0%	0.0%	0.0%	0.0%	0.0%	21.7%	0.0%	0.0%	50.83%	9.00%
66.3%	0.0%	0.0%	0.0%	0.0%	1.3%	32.5%	0.0%	0.0%	63.92%	11.10%
55.6%	0.0%	0.0%	0.0%	0.0%	2.6%	41.9%	0.0%	0.0%	75.35%	13.20%
45.6%	0.0%	0.0%	0.0%	0.0%	3.8%	50.7%	0.0%	0.0%	86.06%	15.31%
35.9%	0.0%	0.0%	0.0%	0.0%	5.0%	59.2%	0.0%	0.0%	96.38%	17.41%
26.4%	0.0%	0.0%	0.0%	0.0%	6.1%	67.5%	0.0%	0.0%	106.47%	19.51%
17.1%	0.0%	0.0%	0.0%	0.0%	7.2%	75.6%	0.0%	0.0%	116.39%	21.61%
8.0%	0.0%	0.0%	0.0%	0.0%	8.3%	83.7%	0.0%	0.0%	126.20%	23.71%
0.0%	0.0%	0.0%	0.0%	0.0%	8.2%	91.8%	0.0%	0.0%	135.93%	25.81%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	145.14%	27.91%

Table 6-15: Global mixed-asset portfolio asset allocation: post-GFC: July 2009–December 2018

Global Stocks	Diversified	Office	Retail	Industrial	Residential	Specialty	US- REITs	EU- REITs	Portfolio return	Portfolio risk
58.9%	0.0%	0.0%	1.1%	15.8%	0.0%	0.0%	24.2%	0.0%	10.12%	12.36%
6.1%	0.0%	0.0%	0.0%	20.2%	0.0%	0.0%	73.7%	0.0%	12.61%	13.70%
0.0%	0.0%	3.7%	0.0%	0.7%	0.0%	0.0%	95.6%	0.0%	13.41%	15.05%
0.0%	0.0%	28.1%	0.0%	0.0%	0.0%	0.0%	71.9%	0.0%	13.65%	16.40%
0.0%	0.0%	42.3%	0.0%	0.0%	0.0%	0.0%	57.7%	0.0%	13.78%	17.74%
0.0%	0.0%	54.0%	0.0%	0.0%	0.0%	0.0%	46.0%	0.0%	13.89%	19.09%
0.0%	0.0%	64.3%	0.0%	0.0%	0.0%	0.0%	35.7%	0.0%	13.98%	20.44%
0.0%	0.0%	73.9%	0.0%	0.0%	0.0%	0.0%	26.1%	0.0%	14.07%	21.78%
0.0%	0.0%	82.9%	0.0%	0.0%	0.0%	0.0%	17.1%	0.0%	14.15%	23.13%
0.0%	0.0%	91.6%	0.0%	0.0%	0.0%	0.0%	8.4%	0.0%	14.23%	24.48%
0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.31%	25.82%

Table 6-15 and **Figure 6-11** present various global portfolio-mix scenarios and their corresponding expected returns and risk in the post-GFC timeframe. In comparison with the pre-GFC performance, the post-GFC global portfolio provided an average return 7,984 base points lower (13.47% p.a. versus 93.31% p.a.) and an average portfolio risk 168 base points higher (19.09% p.a. versus 17.41% p.a.) in comparison with the pre-GFC level. Regional sector-specific REITs (average allocation = 52.6%) maintained a similarly prominent role in the global mixed-asset portfolio to their pre-GFC performance, while allocation to global stocks plunged from 38.8% to 5.9% due to lower average annual returns in the post-GFC investment context. Meanwhile, US-REITs broadened its portfolio compositions to 41.5%.

At the lowest end, the portfolio allocations comprised 8.9% global stocks, 24.2% US-REITs, 15.8% regional industrial REITs and 1.1% regional retail REITs. At this level, the global portfolio registered investment returns and risk of 10.12% p.a. and 12.36%, respectively. At the middle point of the risk-return level, regional office REITs was the main portfolio allocation at 54.0%, followed by 46.0% US-REITs, with portfolio returns and risk of 13.89% p.a. and 19.09%, respectively. At the highest point, regional office REITs reached a maximum level of 100%. Regional office REITs played a prominent role across the broad risk-return band, complementing the portfolio allocations of US-REITs, global stocks and regional industrial REITs when the risk level surged. US-REITs, global stocks and regional industrial REITs largely showed their footprint at the lower end of the risk-return range, since these three assets provided attractive annual returns but comparatively lower annual volatility. Regional diversified REITs and the other regional sector-specific REITs did not play any role across the broad risk-return scale of the optimal mixed-asset portfolio. In short, Asia-Pacific-based sector-specific REITs played a more important role than regional diversified REITs, global stocks, or US- and EU-REITs over two sub-periods. This not only supports the REIT specialisation value in the Asia-Pacific over the two sub-period timeframes, but also elucidates an added-value and strategic role for Asia-Pacific-based sector-specific REITs in the global multi-asset portfolio over these two sub-periods.

Figure 6-12 portrays the comparison of the global mixed-asset portfolio efficient frontiers between the pre- and post-GFC timeframes. As presented in the scatter diagram, the post-

GFC global mixed-asset portfolio efficient frontier was wider and steeper than the pre-GFC curve. The pre-GFC efficient frontier provided greater portfolio returns at each point of its risk-return spectrum than the post-GFC curve. This indicates that the pre-GFC portfolio can produce higher investment returns attached to a lower risk level compared with the post-GFC curve.

Figure 6-11: Global mixed-asset portfolio asset allocation diagram: post-GFC: July 2009–December 2018

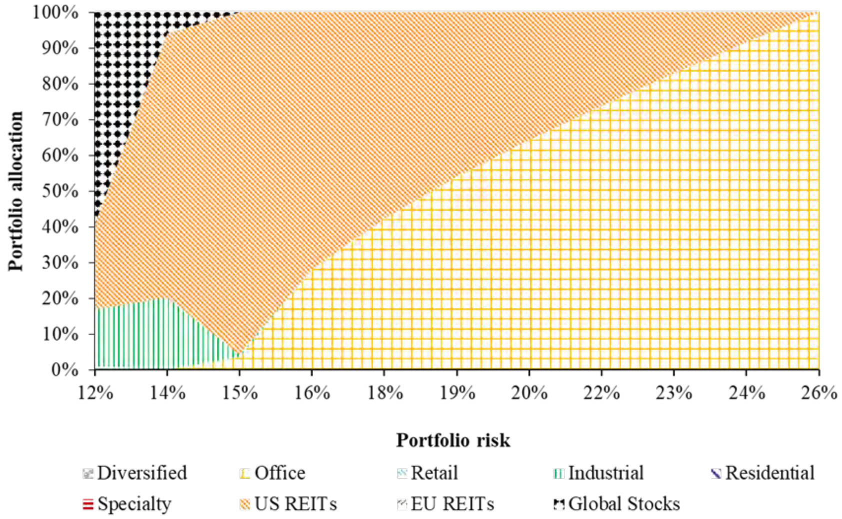
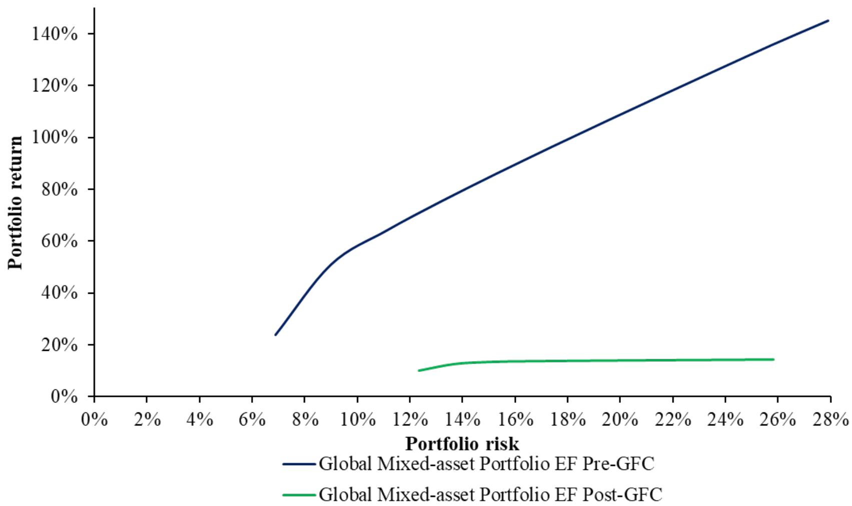


Figure 6-12: Global mixed-asset portfolio efficient frontiers: pre-GFC vs post-GFC



6.3.5 Summary of Findings

Table 6-16 summarises the empirical results of Asia-Pacific-based sector-specific REITs in the global investment framework from July 2006 to December 2018. As presented in Panel A, different property types of regional REITs outperformed regional diversified REITs, global stocks, US- and EU-REITs on a risk-adjusted return basis over the full sample period, particularly prior to the GFC. However, regional sector-specific REITs were inferior to global stocks and US-REITs in the post-GFC investment context due to a higher level of risk. As displayed in Panel B, most regional sector-specific REITs presented greater diversification benefits with global stocks than did their diversified counterparts over the entire sample period, including regional industrial, residential and specialty REITs. The only two exceptions were regional office and retail REITs. In terms of cross-continental inter-REIT portfolio diversifications, different property types of regional REITs provided stronger diversification benefits with US- (average r = 0.56) and EU-REITs (average r = 0.58) than did regional diversified REITs (average r = 0.62; 0.59). This suggests a regional sectoral REIT diversification strategy was superior to a regional inter-REIT diversification strategy. It also indicates a geographic diversification strategy via investing in regional sector-specific REITs could be optimally received by investors seeking portfolio diversifying in the international context through a US-Asia-Pacific or US-Europe diversification approach. Time-varying portfolio diversifications benefits are shown in **Table 6-16**. Larger portfolio diversification benefits for regional sector-specific REITs are documented in the pre-GFC context compared with the post-GFC level.

The prominent role of different property types of regional REITs in the global multi-asset portfolio can be seen in Panel C. In the pre-GFC context, regional specialty REITs (an average allocation = 56.8%) dominated the optimal portfolio allocations, with the minor components being global stocks (38.8%), regional residential REITs (3.9%) and EU-REITs (0.5%). In the post-GFC context, regional office REITs (49.2%) replaced regional specialty REITs as the pre-eminent contributor in the optimal portfolio composition. The average portfolio allocation of US-REITs was 41.5%, with negligible roles for global stocks (5.9%), regional industrial (3.3%) and retail REITs (0.1%). Regional diversified REITs did not play any role in the optimal portfolio composition over the entire study period, including two sub-periods.

Table 6-16: Asia-Pacific-based sector-specific REIT Performance summary: global

Panel A: Return, risk and risk-adjusted return performance

Whole period	Asset	Return	Risk	Risk-adjusted return
(1+2+3+4+5) versus	6	✔	✔	✔
	7	✔	✕	✔
	8	✔	✔	✔
	9	✔	✔	✔
Pre-GFC				
(1+2+3+4+5) versus	6	✔	✔	✔
	7	✔	✕	✔
	8	✔	✔	✔
	9	✔	✔	✔
Post-GFC				
(1+2+3+4+5) versus	6	✔	✔	✔
	7	✔	✕	✕
	8	✔	✕	✕
	9	✔	✔	✔

Panel B: Portfolio diversification benefits

Whole period	1-7	2-7	3-7	4-7	5-7	6-7	(1+2+3+4+5)-8	(1+2+3+4+5)-9
Average *r* =	0.76	0.76	0.63	0.71	0.66	0.75	0.56	0.58
Pre-GFC								
Average *r* =	0.58	0.73	0.81	0.38	0.22	0.82	0.09	0.02
Post-GFC								
Average *r* =	0.68	0.68	0.50	0.66	0.61	0.66	0.56	0.55

Panel C: Asset allocation (%)

Whole period	1	2	3	4	5	6	7	8	9
Average allocation	0.0	2.4	10.7	0.0	53.1	0.0	31.9	1.8	0.0
Pre-GFC									
Average allocation	0.0	0.0	0.0	3.9	56.8	0.0	38.8	0.0	0.5
Post-GFC									
Average allocation	49.2	0.1	3.3	0.0	0.0	0.0	5.9	41.5	0.0

Note: 1 = office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty, 6 = diversified, 7 = global stocks, 8 = US-REITs, 9 = EU-REITs

6.4 SUMMARY OF FINDINGS

This chapter examined the roles of Asia-Pacific-based sector-specific REITs in the regional and global investment contexts from July 2006 to December 2018. In the regional framework, the aggregate regional REITs sub-sectors in the Asia-Pacific (diversified, office, retail, industrial, residential and specialty REITs) were compared with regional stocks and their roles in the regional mixed-asset portfolio were assessed. Similarly, aggregate sector-specific REITs were benchmarked against global stocks, US- and EU-REITs, and their roles in the global mixed-asset portfolio were estimated. The following sections outline the primary findings of this chapter.

6.4.1 Risk-adjusted Performance

The risk-adjusted performance of the aggregate Asia-Pacific-based sector-specific REITs in the regional and global investment contexts from July 2006 to December 2018 is summarised in **Table 6-17**. Within the regional context, regional specialty and industrial REITs were the top two risk-adjusted performers, outperforming regional stocks on a risk-adjusted return basis over the full sample period. All regional sector-specific REITs were superior to regional diversified REITs in terms of risk-adjusted returns. The only exception was regional residential REITs. The sub-period results were generally in line with the full period results. Prior to the GFC, regional specialty REITs was the only REIT sub-sector superior to regional stocks on a risk-adjusted return basis, while most regional REIT sub-sectors were inferior to regional stocks, owing to their higher levels of annual volatility. Post the GFC, regional industrial REITs replaced regional specialty REITs as the best performer in the risk-adjusted return ranking, followed by regional office and specialty REITs. Regional industrial, office and specialty REITs were the only three sub-sectors outpacing regional stocks on a risk-adjusted performance basis, while regional retail, diversified and residential REITs underperformed regional stocks. More importantly, most regional sector-specific REITs offered stronger risk-adjusted returns than their diversified counterparts during the two sub-periods. The exceptions were regional office and residential REITs in the pre-GFC context, and regional residential REITs post-GFC.

In the global context, regional specialty and industrial REITs were the only two REIT sub-sectors superior to global stocks and the US-REITs on a risk-adjusted return basis.

Most regional sector-specific REITs offered higher risk-adjusted returns than the EU-REITs. However, regional residential and diversified REITs were inferior to EU-REITs. The sub-period results are slightly different from the full period outcomes. Prior to the GFC, regional specialty REITs was the only REIT sub-sector outperforming global stocks in terms of risk-adjusted returns, and all regional REIT sub-sectors were superior to the US- and EU-REITs. Post the GFC, all regional sector-specific REITs underperformed global stock and US-REITs on a risk-adjusted return basis. However, most regional REIT sub-sectors were superior to the EU-REIT markets, including regional office, retail, industrial and specialty REITs. The only exception was regional residential REITs. In short, the results highlight that regional sector-specific REITs were the superior risk-adjusted performer compared with diversified REITs and regional stocks in the regional framework, as well as global stocks and US- and EU-REITs in the global framework, over the full study period. However, they were inferior to global stocks and US-REITs in the post-GFC context.

Table 6-17: Asia-Pacific-based sector-specific REIT performance summary: regional and global

Did Asia-Pacific-based sector-specific REITs offer better performance compared with regional and global asset classes?				
	Asset	Return	Risk	Risk-adjusted return
Panel A: Whole period				
Regional	1	✔	✔	✔
	2	✔	✗	✔
Global	1	✔	✔	✔
	3	✔	✗	✔
	4	✔	✔	✔
	5	✔	✔	✔
Panel B: Pre-GFC				
Regional	1	✔	✔	✔
	2	✔	✗	✔
Global	1	✔	✔	✔
	3	✔	✗	✔
	4	✔	✔	✔
	5	✔	✔	✔
Panel C: Post-GFC				
Regional	1	✔	✔	✔
	2	✔	✗	✔
Global	1	✔	✔	✔
	3	✔	✗	✗
	4	✔	✗	✗
	5	✔	✔	✔

Note: 1 = diversified REITs, 2 = Asia-Pacific stocks, 3 = global stocks, 4 = US-REITs, 5 = EU-REITs

6.4.2 Portfolio Diversification Benefits

The inter-asset correlation coefficients of Asia-Pacific-based sector-specific REITs in the regional and global contexts are displayed in **Table 6-18**. Different property types of regional REITs delivered stronger diversification benefits with regional stocks than did their diversified counterparts in the regional investment framework over the full sample period, including two sub-periods. At the same time, regional sector-specific REITs offered more attractive diversification benefits with global stocks, US- and EU-REITs than did regional diversified REITs in the global investment framework.

Within the regional and international investment strategies, this chapter has discovered that diversification within regional sector-specific REITs and diversified REITs was not attractive to investors seeking portfolio diversification in the Asia-Pacific over the full study period (average $r = 0.69$), including the pre-GFC (average $r = 0.63$) and post-GFC periods (average $r = 0.67$). This is due to that a diversified REIT portfolio comprises various types of property sectors. On the other hand, diversification within various property types of regional REITs was generally more appealing to investors compared with diversifications within all regional REIT sub-sectors over the entire study period, particularly in the pre-GFC investment context (average $r = 0.40$). This indicates a sectoral REIT investment strategy could provide greater diversification benefits for investors seeking portfolio diversifying in the Asia-Pacific region.

Time-varying portfolio diversifications benefits with regional and global asset classes for different property types of regional REITs are observed in **Table 6-18**. The post-GFC performance of regional sector-specific REITs was not comparable with the pre-GFC level. Nonetheless, regional sector-specific REITs offered more attractive cross-continental inter-REIT portfolio diversification benefits than their diversified counterparts in the post-GFC investment context. This shows that a geographic diversification strategy using Asia-Pacific-based sector-specific REITs could be optimally received by investors through an Asia-Pacific-US or Asia-Pacific-Europe diversification approach over the entire study period, particularly prior to the GFC.

Table 6-18: Asia-Pacific-based sector-specific REIT correlation coefficient summary: regional and global

	1-3	2-3	1-4	2-4	1-5	2-5	1-6	2-6	1-2	1-1
Panel A: Whole period										
	0.72	0.74	0.70	0.75	0.56	0.62	0.58	0.59	0.69	0.63
Panel B: Pre-GFC										
	0.55	0.74	0.54	0.82	0.09	0.36	0.02	0.15	0.62	0.40
Panel C: Post-GFC										
	0.64	0.64	0.63	0.66	0.56	0.67	0.55	0.61	0.67	0.63

Note: 1 = sector-specific REITs, 2 = diversified REITs, 3 = Asia-Pacific stocks, 4 = global stocks, 5 = US-REITs, 6 = EU-REITs

6.4.3 Roles in Regional and Global Mixed-asset Portfolios

The role of different property types of regional REITs in regional and global mixed-asset portfolios was assessed over the entire study period, including two sub-periods (**Table 6-19**). In the regional framework, the mean-variance analysis indicates that regional sector-specific REITs (average allocation = 74.2%) formed the majority of the optimal portfolio composition over the full study period, while regional stocks (25.8%) contributed a quarter of the portfolio allocations. However, regional diversified REITs did not play any role in the optimal asset allocations. In the global framework, regional sector-specific REITs dominated the global mixed-asset portfolio, with an average allocation of 66.3% over the full study period. Meanwhile, global stocks and US-REITs had relatively minor roles in the optimal portfolio compositions, with an average portfolio allocation of 31.9% and 1.8%, respectively. Regional diversified REITs did not play any role in the optimal portfolio allocations.

The sub-period results show the stronger contribution of regional sector-specific REITs in the regional and global mixed-asset portfolios compared with the other regional and global asset classes in the sub-period analysis. Within the regional framework, regional sector-specific REITs enlarged portfolio compositions in the post-GFC investment context compared with the pre-GFC period (from 64.0% to 86.1%), while regional stocks dwindled as a proportion of the optimal portfolio allocations (from 36.0% to 13.9%). Within the global framework, regional sector-specific REITs maintained their prominent role across the two sub-periods, while global stocks significantly decreased its portfolio compositions in the post-GFC context (from 38.8% to 5.9%), and US-REITs broadened its portfolio allocations in the post-GFC context (from 0.0% to 41.5%). During two sub-periods, regional REITs did not feature in the optimal portfolio composition. Regional sector-specific REITs were found across the entire risk-return range, while the other regional and global assets were only present at the lower end of the risk-return spectrum.

In short, these facts suggest that Asia-Pacific-based sector-specific REITs were favoured over regional diversified REITs, as well as over regional and global asset classes, over the full sample period. In addition, regional sector-specific REITs were an added-value and strategic portfolio component for both risk-averse and risk-taking investors over the past 12 years, featuring across the whole risk-return scale. Compared with the other regional and global asset classes, they were comparatively high-risk investment assets since most of their portfolio allocations were embedded in the higher end of the risk-return spectrum.

Table 6-19: Asia-Pacific-based sector-specific REIT asset allocation summary: regional and global

	Sector-specific REITs	Diversified REITs	AP stocks	Global stocks	US-REITs	EU-REITs
Panel A: Whole period						
Regional	74.2%	0.0%	25.8%	—	—	—
Global	66.3%	0.0%	—	31.9%	1.8%	0.0%
Panel B: Pre-GFC						
Regional	64.0%	0.0%	36.0%	—	—	—
Global	56.8%	0.0%	—	38.8%	0.0%	0.5%
Panel C: Post-GFC						
Regional	86.1%	0.0%	13.9%	—	—	—
Global	52.6%	0.0%	—	5.9%	41.5%	0.0%

6.5 SUMMARY OF CHAPTER

The findings in this chapter confirm the prominent role of Asia-Pacific-based sector-specific REITs in regional and global mixed-asset portfolios compared with regional diversified REITs, as well as the other regional and global asset classes, over the full study timeframe, including two sub-periods. The findings support the existence of REIT specialisation value in the Asia-Pacific from July 2006 to December 2018, by comparing different property types of regional REITs and diversified REITs for the first time. A geographic diversification strategy using regional sector-specific REITs could be optimally received investors by employing an Asia-Pacific-US or Asia-Pacific-Europe diversification approach. This suggests that investors seeking listed property exposure in the Asia-Pacific should actively control their own portfolio allocations and diversifications by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio with multiple property sectors.

This chapter has analysed regional and international investment strategies. The next chapter extends the analysis to the portfolio returns, risk, diversifications and asset allocations of five different property types of regional REIT-based portfolio, to reflect the practical implications for institutional investors constructing regional REIT-based portfolios rather than country-specific REIT-based portfolios.

CHAPTER 7
THE SIGNIFICANCE AND PERFORMANCE OF DIFFERENT PROPERTY TYPES OF ASIA-PACIFIC REIT-BASED PORTFOLIOS

Chapter 7 assesses the returns, risk, risk-adjusted returns and portfolio diversification benefits of cross-country sector-specific REITs across Japan, Australia and Singapore from July 2006 to December 2018, benchmarked against the USA. The portfolio returns, risk, geographic and sectoral diversifications and asset allocations of five different property types – office, retail, industrial, residential and specialty – in regional REIT-based portfolios will also be assessed, in order to reflect the fact that international property investors with capital have a mandate to gain exposure to regional REIT-based portfolios, rather than country-specific REIT portfolios. The results for regional industrial REIT-based portfolios in the Asia-Pacific were externally validated by the author in a Journal of Property Investment & Finance article titled "The added-value role of industrial and logistics REITs in the Pacific Rim region", in which the regional I&L REIT-based portfolio was used for the robustness check, in order to highlight the added-value and strategic role of I&L REITs in the Pacific Rim region.

7.1 INTRODUCTION

The two preceding chapters introduced the performance of Asia-Pacific sector-specific REITs in domestic, regional and global mixed-asset portfolios. However, one could make a case that a fund, particularly REMFs/PSFs and international REIT investors, could have a mandate to invest in a regional REIT-based portfolio from a practical point of view, rather than building country-specific REIT portfolios. This chapter explores risk-return profiles (as measured by the return/risk ratio) of five different property types of regional REIT-based portfolios in the Asia-Pacific investment context based on a single sector-specific REIT framework from July 2006 to December 2018 (RQ4). The cross-country frameworks include the construction of regional office, retail, industrial, residential and specialty REIT-based portfolios in the Asia-Pacific region. Each optimal portfolio is composed of the corresponding REIT sub-sectors in Japan, Australia and Singapore, benchmarked against the USA. The portfolio was constructed and measured in US dollars to mitigate the currency risk for international property investors. The optimal weights of cross-country sector-specific REIT in regional REIT-based portfolios are identified. Geographic and sectoral REIT investment strategies across Japan, Australia, Singapore and the USA are explored. The sub-period analysis is employed to capture the dynamics of these five types of regional REIT-based portfolios in the Asia-Pacific region.

This chapter is structured as follows. Section 7.2 introduces risk-return profiles of regional office REIT-based portfolios in the Asia-Pacific. Section 7.3 illustrates risk-return attributes of regional retail REIT-based portfolios in the Asia-Pacific. Section 7.4 offers the portfolio returns and risk of regional industrial REIT-based portfolios in the Asia-Pacific. Section 7.5 provides the performance analysis of regional residential REIT-based portfolios in the Asia-Pacific. Section 7.6 demonstrates the performance analysis of regional specialty REIT-based portfolios in the Asia-Pacific. Finally, Section 7.7 summarises the strategic investment implications of this chapter.

7.2 PERFORMANCE OF ASIA-PACIFIC OFFICE REIT-BASED PORTFOLIO

7.2.1 Risk-adjusted Performance Analysis

To reflect international property investors having a mandate to gain exposure to office REITs in the Asia-Pacific, a regional office REIT-based portfolio was analysed from July 2006 to December 2018. **Table 7-1** presents annual returns, annual risk and risk-adjusted returns for office REITs in the USA, Japan, Australia and Singapore over the study period. The results indicate that Singapore posted the highest average annualised returns at 6.36% p.a. among the four office REIT markets, followed by Japan (6.00% p.a.), Australia (5.15% p.a.) and the USA (2.53% p.a.). The risk level of Singapore (average risk = 27.96%) was the highest among the four markets, ahead of Japan (21.12%), the USA (25.04%) and Australia (25.48%). On a risk-adjusted return basis (via the return/risk ratio), Japan (0.28) overtook the other three markets to become the best performer, while Singapore (0.23) was ranked as the second-best risk-adjusted performer in the portfolio due to its high-risk level. They were followed by Australia (0.20) and the USA (0.10).

Table 7-1: Asia-Pacific office REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
US	2.53	25.04	0.10	4
Japan	6.00	21.12	0.28	1
Australia	5.15	25.48	0.20	3
Singapore	6.36	27.96	0.23	2

Note: *US dollars

7.2.2 Diversification Benefit Analysis

To assess portfolio diversification benefits for an Asia-Pacific office REIT investment strategy, a correlation coefficient analysis was conducted for the data from July 2006 to December 2018, as reported in **Table 7-2**. Using Asia-Pacific office REIT monthly total return series, it is evident that there were attractive and strong portfolio diversification benefits (average $r = 0.52$) among office REITs in these four markets. The only exception is the correlation between Australia and Singapore ($r = 0.73$).

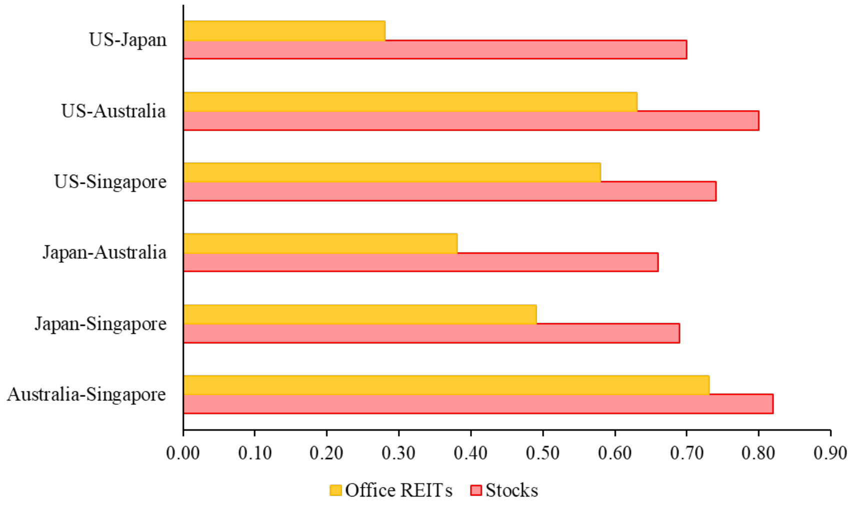
Table 7-2: Asia-Pacific office REIT correlation analysis*: July 2006–December 2018

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.28*	1.00		
Australia	0.63*	0.38*	1.00	
Singapore	0.58*	0.49*	0.73*	1.00

Note: *Significant correlation (p<5%)

Figure 7-1 compares geographic diversification benefits between inter-office REITs and inter-stock investment perspectives over the entire study period. Investors searching for a cross-country inter-Asia-Pacific office REIT (average $r = 0.52$) investment strategy would receive 22% more geographic diversifications compared with investing in a cross-country inter-stock (average $r = 0.74$) investment framework in the region. Within a cross-country inter-office REIT investment framework, the strongest geographic diversification can be achieved by utilising a US-Japan diversification approach ($r = 0.28$), followed by Japan-Australia ($r = 0.45$), Japan-Singapore ($r = 0.48$), US-Singapore ($r = 0.50$), US-Australia (0.60) and Australia-Singapore ($r = 0.70$) approaches.

Figure 7-1: Country correlation: office REITs vs stocks: July 2006–December 2018



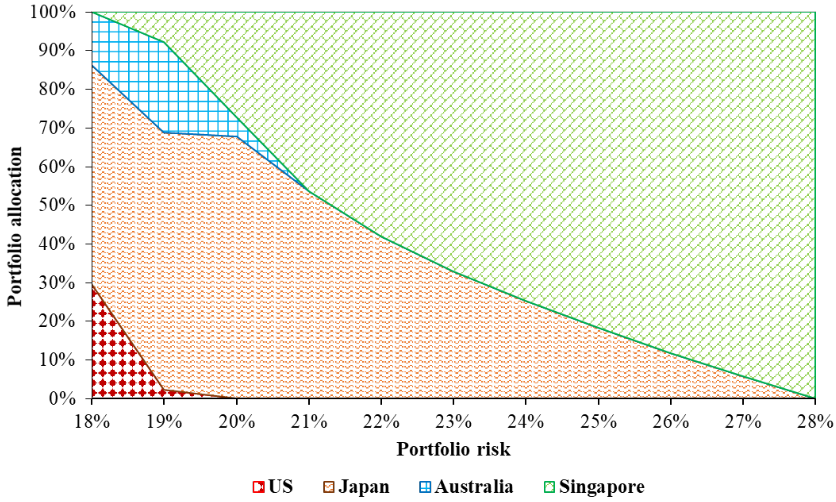
7.2.3 Portfolio Analysis

Table 7-3 lists the portfolio compositions of a cross-country office REIT-based portfolio constructed using the mean-variance optimisation process based on office REITs across the USA, Japan, Australia and Singapore from July 2006 to December 2018. The expected portfolio returns and risk levels for various optimised portfolios are also highlighted in **Figure 7-2**, depicting the contributions of office REITs in these four markets to portfolio structures. Singapore (average allocation = 58.7%) played a significant role across the whole risk-return band within the regional office portfolio, while Japan (34.6%) was the second-best performer in the optimal regional office portfolio. Singapore mainly featured in the higher end of the risk-return range and displaced the portfolio compositions of Japan when the risk level heightened. This is because Singapore posted higher average annual returns and higher risk levels than with Japan. The portfolio allocations of Japan were mostly embedded in the lower end of the risk-return scale, since it registered the lowest annual risk level of the four office REIT markets. On the other hand, since Australia (3.8%) and the USA (2.9%) offered very low average annual returns and higher volatility, they had minor roles in the lower end of the risk-return band and were joined by Singapore and Japan when the risk level heightened. In addition, they were strongly correlated with Singapore.

Table 7-3: Asia-Pacific office REIT asset allocation: July 2006–December 2018

US	Japan	Australia	Singapore	Portfolio return	Portfolio risk
29.7%	56.6%	13.7%	0.0%	4.86%	18.01%
2.4%	66.6%	23.4%	7.7%	5.75%	19.01%
0.0%	67.8%	4.9%	27.3%	6.06%	20.00%
0.0%	53.7%	0.0%	46.3%	6.17%	21.00%
0.0%	41.9%	0.0%	58.1%	6.21%	21.99%
0.0%	33.0%	0.0%	67.0%	6.24%	22.99%
0.0%	25.2%	0.0%	74.8%	6.27%	23.98%
0.0%	18.3%	0.0%	81.7%	6.30%	24.97%
0.0%	11.9%	0.0%	88.1%	6.32%	25.97%
0.0%	5.8%	0.0%	94.2%	6.34%	26.96%
0.0%	0.0%	0.0%	100.0%	6.36%	27.96%

Figure 7-2: Asia-Pacific office REIT asset allocation diagram: July 2006–December 2018



7.2.4 Sub-period Analysis

The empirical results of the performance analysis for Asia-Pacific office REITs over two sub-periods are displayed in **Table 7-4**. The risk and return profiles of office REITs in these four markets were highly volatile over the two sub-period timeframes, particularly in relation to average annual returns. Before the GFC, Singapore (47.61% p.a.), Australia (41.41% p.a.) and Japan (37.04% p.a.) offered attractive average annual returns at more than 35% p.a. They were clearly superior to the USA (4.28% p.a.). The risk levels of office REITs in these four markets were comparable with one another. This resulted in inferior risk-adjusted performance (via the return/risk ratio) for the USA (0.22) compared with office REITs in the other three markets. Specifically, Australia (3.08) outpaced the other three markets to become the best risk-adjusted performer for its comparatively lower annual volatility (13.46%). It was followed by Singapore (2.41) and Japan (1.59), since these two assets featured higher risk levels than Australia.

After the GFC, office REITs in these four markets maintained their annual risk levels at the pre-GFC level. However, average annualised returns for office REITs across these four markets slipped from 32.59% p.a. (pre-GFC) to 10.79% p.a. (post-GFC). As a result, office REITs across these four markets produced poorer risk-adjusted performance in the post-GFC context compared with pre-GFC levels. The only exception is the USA, since it increased average annual returns from 4.28% p.a. (pre-GFC) to 10.22% p.a. (post-GFC).

Specifically, Australia (0.77) was the best risk-adjusted performer, as it offered the highest average annual returns at 13.00% p.a., slightly outperforming Singapore (0.63), the USA (0.57) and Japan (0.45). Japan was the lowest performing risk-adjusted asset since it offered the lowest average annual returns at 8.42% p.a.

Table 7-4: Asia-Pacific office REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
US	4.28	19.09	0.22	4
Japan	37.04	23.32	1.59	3
Australia	41.41	13.46	3.08	1
Singapore	47.61	19.75	2.41	2
Panel B: Post-GFC: July 2009–December 2018				
US	10.22	17.85	0.57	3
Japan	8.42	18.80	0.45	4
Australia	13.00	16.98	0.77	1
Singapore	11.51	18.14	0.63	2

Note: *US dollars

Figure 7-3 plots risk-return profiles of office REITs in the USA, Japan, Australia and Singapore based on the results of the earlier risk-adjusted return analysis, benchmarked against regional and US stocks. In the pre-GFC context (Panel A), Japan, Australia and, particularly, Singapore are positioned in the upper-right quadrant of the scatter diagram, offering the highest average annual returns and comparatively lower volatility. This implies that they offered higher investment returns while exposing investors to a higher level of volatility in comparison with regional and US stocks. On the other hand, the USA is plotted in the lower-right quadrant of the scatter diagram because it was seen as a lower-return/higher-risk investment asset.

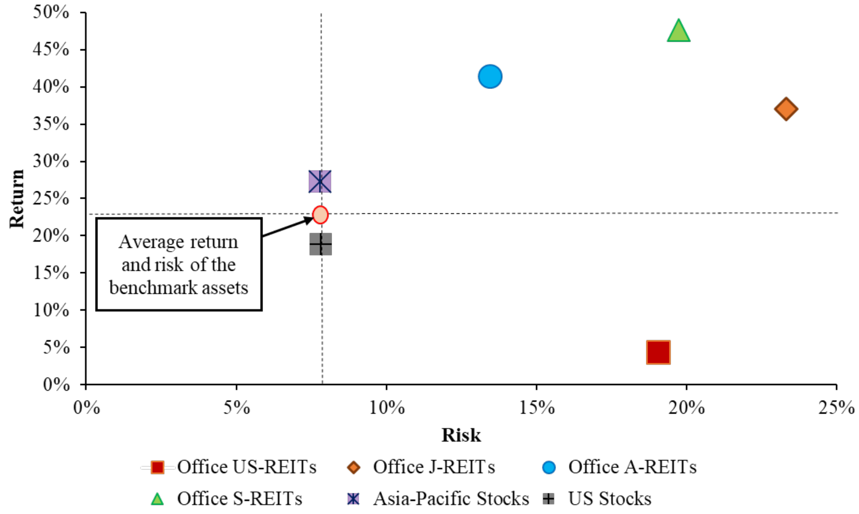
In the post-GFC context (Panel B), three of four office REITs are seen in the higher-return/higher-risk quadrant of the scatter diagram, namely Australia, Singapore and the USA. Japan was the only office REITs market in the region exhibiting a below-average return level. Compared with the regional stocks located in the lower-right section of the scatter diagram, the four office REITs were attractive high-risk investment propositions for investors seeking listed property exposure in the region. In particular, Australia had the potential to post greater investment returns with a higher risk level compared with US stocks. In brief, the results indicate that Asia-Pacific office REITs were classified as a higher-return/higher-risk investment asset over the two sub-period timeframes. This is not expected for a listed property investment asset, which traditionally features low-return/low-risk attributes.

Table 7-5 presents the dynamic portfolio diversification benefits for an Asia-Pacific office REIT investment strategy by conducting a correlation coefficient analysis of office REITs in the USA, Japan, Australia and Singapore over the two sub-periods. These results suggest that both the pre-GFC (average $r = 0.44$) and post-GFC (average $r = 0.48$) Asia-Pacific office REIT investment strategies provided attractive portfolio diversification benefits for investors. Before the GFC (Panel A), it is evident that there was a moderately strong linear relationship between the monthly returns of the USA and Japan ($r = 0.62$). Conversely, investors could obtain better portfolio diversification benefits by combining Japan and Australia ($r = 0.22$) in an office REIT-based portfolio.

After the GFC (Panel B), however, as Australia was strongly correlated with Singapore ($r = 0.79$), investors would achieve less portfolio diversification benefits by including these two assets in a portfolio. The USA and Australia ($r = 0.68$) offered less desirable portfolio diversification benefits for investors seeking portfolio diversifying in the region, as did the USA and Singapore ($r = 0.56$). In contrast, the correlation coefficient for the USA and Japan ($r = 0.19$) delivered conspicuous enhancement in portfolio diversifications.

Figure 7-3: Sub-period risk and return profiles of Asia-Pacific office REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

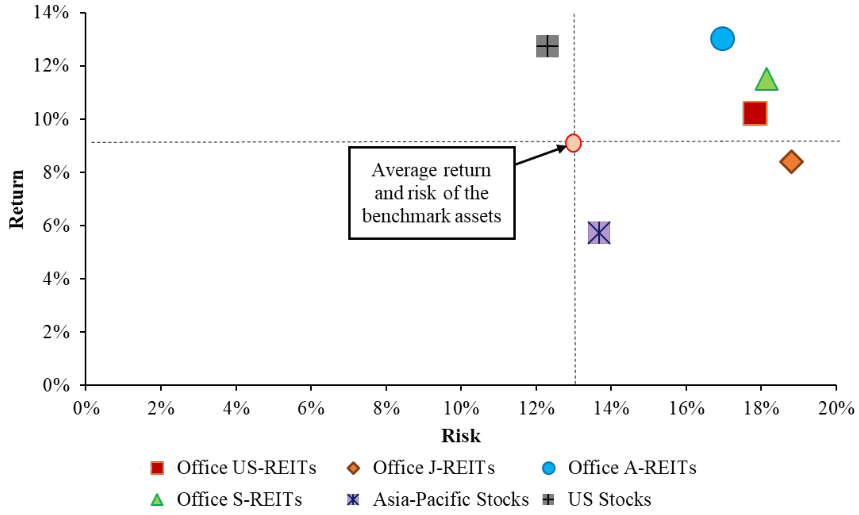


Figure 7-4 illustrates the comparisons of geographic diversification benefits between inter-office REIT and inter-stock investment perspectives over the sub-period timeframes, including the pre-GFC (Panel A) and post-GFC periods (Panel B). The post-GFC results generally show that a cross-country inter-office REIT (average $r = 0.48$) investment strategy offered 18% more geographic diversifications compared with an inter-stock (average $r = 0.66$) investment framework. The only exception is an inter-office REIT investment framework via an Australia-Singapore approach ($r = 0.79$), which was higher than an inter-stock investment framework ($r = 0.78$) with the same vehicle. However, the pre-GFC results indicate that an inter-stock (average $r = 0.42$) investment framework offered comparable geographic diversifications to an inter-office REIT (average $r = 0.44$)

investment framework. Specifically, it had 75% and 4% more geographic diversifications compared with an inter-office REIT framework via the approaches of US-Japan and Japan-Singapore, respectively.

Table 7-5: Asia-Pacific office REIT correlation analysis*

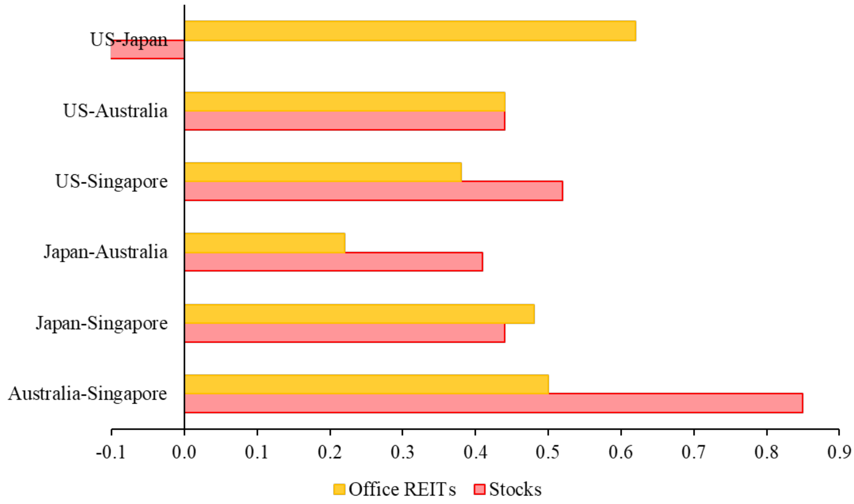
Panel A: Pre-GFC: July 2006–September 2007	US	Japan	Australia	Singapore
US	1.00			
Japan	0.62*	1.00		
Australia	0.44	0.22*	1.00	
Singapore	0.38	0.48*	0.50*	1.00
Panel B: Post-GFC: July 2009–December 2018	**US**	**Japan**	**Australia**	**Singapore**
US	1.00			
Japan	0.19*	1.00		
Australia	0.68*	0.28*	1.00	
Singapore	0.56*	0.35*	0.79*	1.00

Note: *Significant correlation (p<5%)

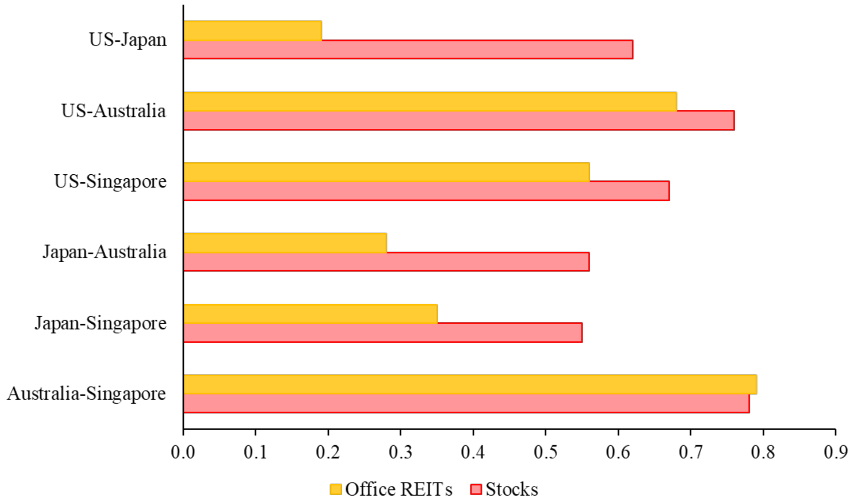
Figure 7-5 displays the optimal portfolio allocations for cross-country office REITs across the USA, Japan, Australia and Singapore over the pre-GFC (Panel A) and post-GFC timeframes (Panel B). Prior to the GFC, Singapore (average allocation = 64.1%) and Australia (32.6%) dominated across the whole risk-return range, due to their strong average annual returns, low annual risk levels and low correlations with the other office REIT markets in the region. Despite being the best risk-adjusted performer, Japan mainly featured in the lower end of the risk-return scale, complemented by Singapore, registering the highest average returns at 47.61% p.a. Singapore enhanced its portfolio compositions in the higher end of the risk-return range as a high-risk investment asset. In contrast, Japan (2.6%) and the USA (0.8%) only featured at the start of the risk-return scale, replaced by Singapore and Australia when the risk level heightened.

Figure 7-4: Sub-period country correlation: office REITs vs stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018



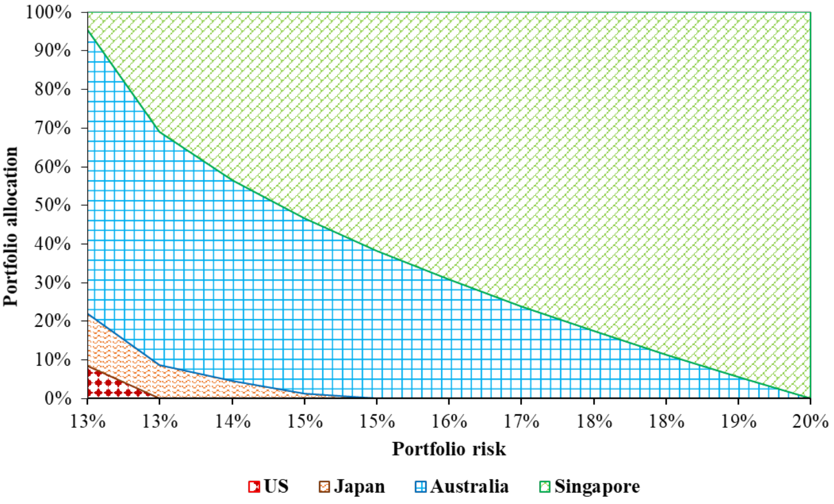
Post the GFC, Australia (75.7%) played an exceptional role across the whole risk-return band, due to having the highest average annual returns and the lowest risk level among the four office REIT markets. Despite being the second-best risk-adjusted performer, Singapore (1.0%) was only positioned at the start of the risk-return range, since it was strongly correlated with Australia ($r = 0.79$). As such, Singapore was largely overshadowed by Australia in the optimal office REIT-based portfolio. Additionally, the minor role of Japan (16.8%) can be seen across the broad risk-return scale, particularly in the lower end of the risk-return band, owing to its low correlations with the other office REITs in the region. It replaced the USA (6.4%) at the start of the risk-return scale, but is joined by Australia when the risk level increases.

The comparison of office REIT-based efficient frontiers between the pre-GFC and post-GFC periods is exhibited in **Figure 7-6**. As depicted in the line charts, the pre-GFC office REIT efficient frontier was higher and longer than the post-GFC curve. The pre-GFC portfolio not only delivered substantial increments in the efficient frontiers, but also allowed for a wider risk-return band. This confirms that the pre-GFC Asia-Pacific office REITs were an important investment for both risk-averse and risk-taking investors. In other words, office REIT-based portfolio performance slipped by 2,700 to 3,400 base points from the pre-GFC level. On the other hand, the risk ranges of the post-GFC efficient frontier were more constrained, from 14 to 276 base points.

Overall, the results of this section show that office REITs across these four jurisdictions were high-return/high-risk investment assets, except for office US-REITs in the pre-GFC context. In addition, a cross-country inter-Asia-Pacific office REIT investment strategy provided strong portfolio diversification benefits for investors seeking portfolio diversifying in the region. However, the strong correlation between Australia and Singapore is noteworthy, particularly after the GFC. Within the cross-country office REIT-based portfolio, Australia outdid the other three markets to become the best risk-adjusted performer, due to having the highest average annualised returns and the lowest volatility over the two sub-periods; it was followed by Singapore, Japan and the USA. Nevertheless, Singapore was largely complemented by Australia within the regional post-GFC office REIT-based portfolio, owing to their strong correlations.

Figure 7-5: Asia-Pacific office REIT sub-period asset allocation diagram

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

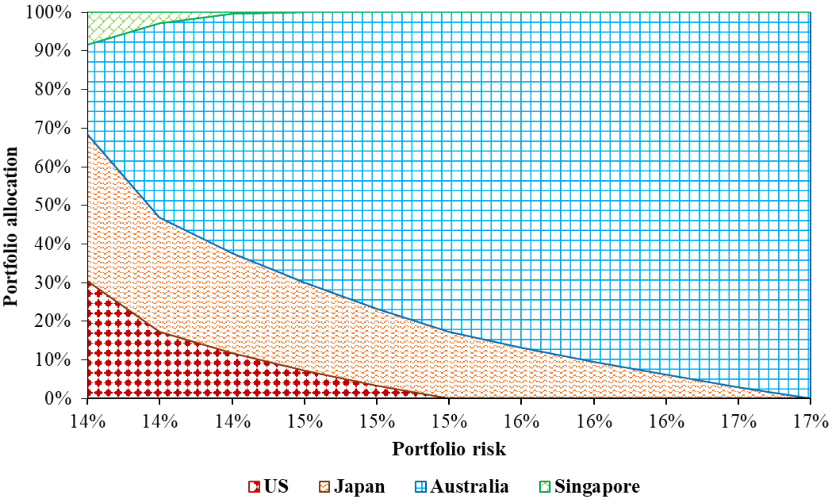
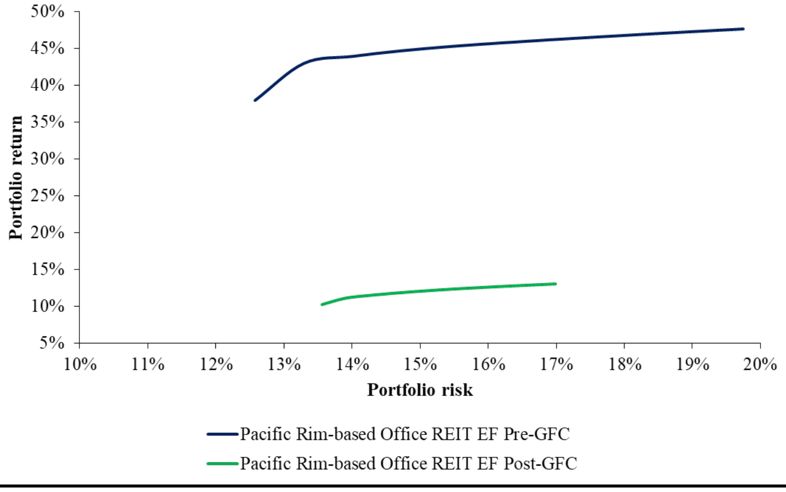


Figure 7-6: Asia-Pacific Office REIT-based Efficient Frontiers: Pre-GFC vs Post-GFC



7.3 PERFORMANCE OF ASIA-PACIFIC RETAIL-BASED REIT PORTFOLIO

7.3.1 Risk-adjusted Performance Analysis

Table 7-6 lists the risk-adjusted performance for retail REITs across the USA, Japan, Australia and Singapore from July 2006 to December 2018. The results show that Singapore registered higher average annual returns at 8.86% p.a. than the other retail REITs in the region. It surpassed Japan (5.27% p.a.), Australia (3.55% p.a.) and the USA (3.51% p.a.) over the full study timeframe. The risk level for Australia (annual risk = 16.95%) was the lowest among the four retail REIT markets in the region. The volatility of the other three retail REITs was higher than 20% over the whole study period – Singapore (21.73%), Japan (21.88%) and the USA (27.67%). In terms of risk-adjusted returns (via the return/risk ratio), Singapore (0.41) markedly outpaced the other retail REITs in the region. Japan (0.24) was the second-best risk-adjusted performer within the regional retail REIT-based portfolio, closely followed by Australia (0.21) and the USA (0.13).

Table 7-6: Asia-Pacific retail REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
US	3.51	27.67	0.13	4
Japan	5.27	21.88	0.24	2
Australia	3.55	16.95	0.21	3
Singapore	8.86	21.73	0.41	1

Note: *US dollars

7.3.2 Diversification Benefit Analysis

Table 7-7 illustrates the inter-retail REIT correlation matrix from July 2006 to December 2018. Investors seeking a cross-country inter-Asia-Pacific retail REIT investment strategy would receive strong portfolio diversification benefits (average $r = 0.52$). Nonetheless, the correlation coefficients of Australia with Singapore and the USA were 0.76 and 0.64, respectively. In contrast, the correlation measures of Japan with Singapore and the USA were 0.49 and 0.30, respectively. These figures indicate that Asia-Pacific retail REIT investors could achieve greater portfolio diversification benefits by adding Japan rather than Australia to their portfolio over the full study timeframe.

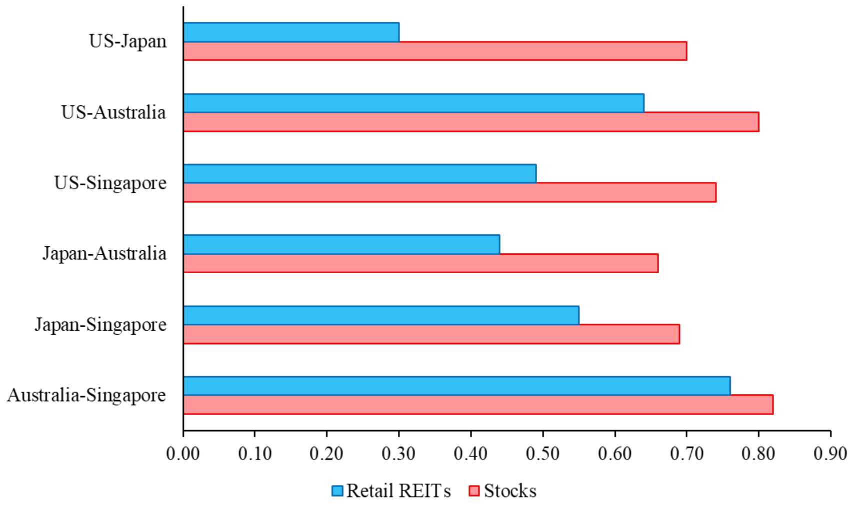
Figure 7-7 graphs the comparisons of geographic diversification benefits between inter-retail REIT and inter-stock investment perspectives over the entire study period. International investors searching for geographic diversifying in the Asia-Pacific region and the US investment context could achieve greater benefits by using a cross-country inter-retail REIT (average $r = 0.53$) investment strategy than a cross-country inter-stock investment strategy (average $r = 0.74$). Within an inter-retail REIT investment framework, a US-Japan diversification approach ($r = 0.30$) provided the highest geographic portfolio diversification, followed by Japan-Australia ($r = 0.44$), US-Singapore ($r = 0.49$), Japan-Singapore ($r = 0.55$), US-Australia (0.64) and Australia-Singapore (0.76) approaches.

Table 7-7: Asia-Pacific retail REIT correlation analysis*: July 2006–December 2018

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.30*	1.00		
Australia	0.64*	0.44*	1.00	
Singapore	0.49*	0.55*	0.76*	1.00

Note: *Significant correlation (p<5%)

Figure 7-7: Country correlation: retail REITs vs stocks: July 2006–December 2018



7.3.3 Portfolio Analysis

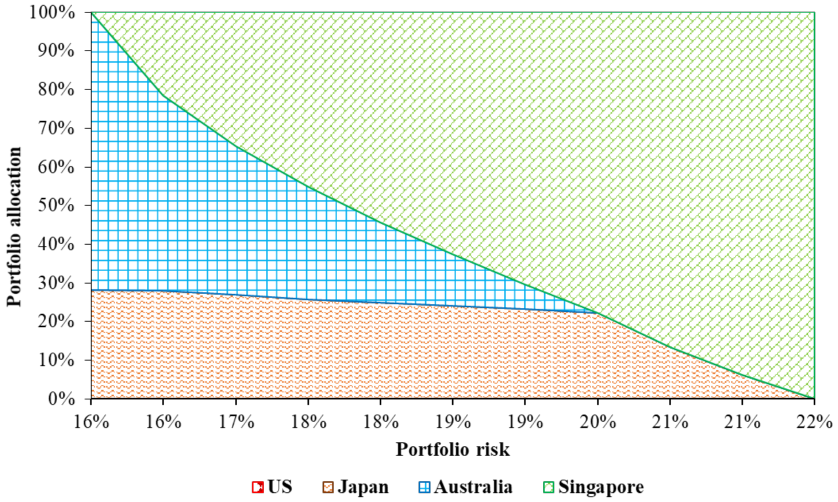
The mean-variance optimal portfolio allocations for cross-country retail REITs across the USA, Japan, Australia and Singapore from July 2006 to December 2018 are shown in **Table 7-8**. **Figure 7-8** depicts the portfolio compositions of these four retail REIT markets relative to the portfolio risk level.

Singapore (average allocation = 58.8%) dominated across the whole risk-return scale within the regional retail REIT-based portfolio, owing to having the highest average annual returns and comparatively lower annual volatility than all retail REITs in the region. Specifically, it replaced Australia (20.9%) and Japan (20.3%) when the risk level surged, while the USA did not play any role in the optimal portfolio allocations. Additionally, Japan enlarged its portfolio allocations by overshadowing Australia in the higher end of the risk-return range. This was driven by higher average annual returns and higher risk levels for Japan compared those for Australia.

Table 7-8: Asia-Pacific retail REIT asset allocation: July 2006–December 2018

US	Japan	Australia	Singapore	Portfolio return	Portfolio risk
0.0%	28.3%	71.7%	0.0%	4.03%	15.87%
0.0%	28.0%	50.4%	21.6%	5.18%	16.46%
0.0%	26.9%	38.5%	34.6%	5.85%	17.05%
0.0%	25.7%	29.1%	45.2%	6.39%	17.63%
0.0%	24.8%	20.8%	54.4%	6.86%	18.22%
0.0%	24.0%	13.3%	62.7%	7.29%	18.80%
0.0%	23.3%	6.3%	70.4%	7.68%	19.39%
0.0%	22.3%	0.0%	77.7%	8.06%	19.98%
0.0%	13.5%	0.0%	86.5%	8.37%	20.56%
0.0%	6.3%	0.0%	93.7%	8.63%	21.15%
0.0%	0.0%	0.0%	100.0%	8.86%	21.73%

Figure 7-8: Asia-Pacific retail REIT asset allocation diagram: July 2006–December 2018



7.3.4 Sub-period Analysis

Table 7-9 tabulates the risk-adjusted performance of retail REITs across the USA, Japan, Australia and Singapore over two sub-periods. Generally, the average annual returns of Australia and Singapore changed significantly over the two sub-periods, while risk-return profiles of Japan and the USA were comparatively stable. Prior to the GFC, Singapore registered the highest average annualised returns at 59.12% p.a. with the second-lowest annual risk of 21.53%, and was rated as the best risk-adjusted performer (return/risk ratio = 2.75) of all retail REITs in the region. It outperformed Australia (2.51), the USA (0.73) and Japan (0.64) on a risk-adjusted return basis. Australia, the second-best risk-adjusted performer, offered the second-highest average annual returns at 31.48% p.a. and the lowest annual volatility at 12.52%.

Post the GFC, the USA (0.73) overtook Singapore (0.72) to become the best risk-adjusted performer, due to having the highest average annual returns at 13.10% p.a. Meanwhile, the USA and Singapore outperformed Japan (0.50) and Australia (0.40). With the second-highest average annual returns at 11.17% p.a., Singapore had the lowest risk level at 15.50%. In contrast, Australia offered the lowest average annual returns at 5.90% p.a. and the lowest annual volatility at 14.78%.

Table 7-9: Asia-Pacific retail REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
US	15.87	21.87	0.73	3
Japan	14.05	21.86	0.64	4
Australia	31.48	12.52	2.51	2
Singapore	59.12	21.53	2.75	1
Panel B: Post-GFC: July 2009–December 2018				
US	13.10	18.03	0.73	1
Japan	9.27	18.39	0.50	3
Australia	5.90	14.78	0.40	4
Singapore	11.17	15.50	0.72	2

Note: *US dollars

The risk-return scatter diagrams of the four retail REITs in the region benchmarked against the Asia-Pacific stocks and the US stocks over two sub-period timeframes are shown in **Figure 7-9**. As seen on the risk-return plane of Panel A, Singapore and Australia were superior to regional and US stocks in the pre-GFC context. In other words, Singapore and Australia produced higher returns by exposing investors to a higher risk level. It is evident that Singapore and Australia are tied in the upper left portion of the scatter plot, which is the high-return/high-risk quadrant. In contrast, the USA and Japan had a below-average return level but an above-average risk level, positioning them in the lower-return/higher-risk quadrant of the scatter diagram. This implies that the USA and Japan were inferior to the benchmark assets as investment options.

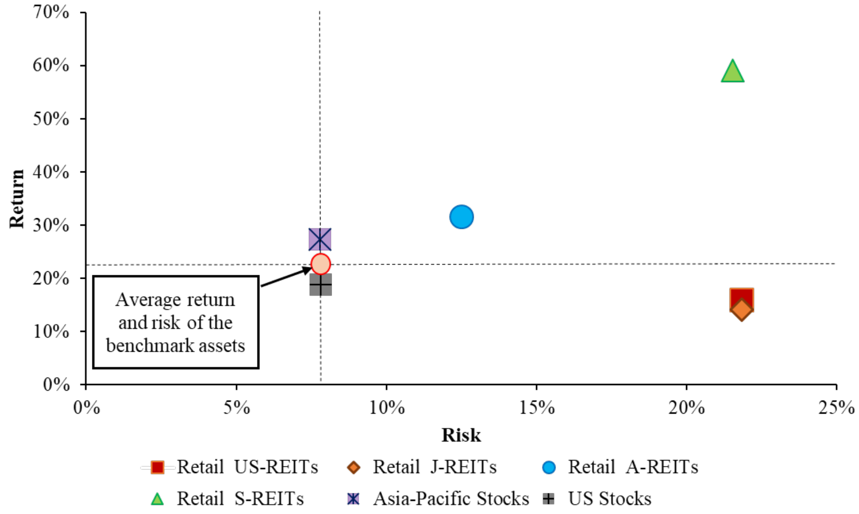
In the post-GFC context (Panel B), three of four retail REITs in the region were mapped in the higher-return/higher-risk quadrant of the scatter diagram, including the USA, Singapore and Japan. This indicates that most retail REITs in the region were seen as higher-return/higher-risk investment assets. The exception is Australia, which is located in the lower-right quadrant of the risk-return diagram and below the average risk level. This shows that Australia provided poorer investment returns but had a higher level of volatility.

In brief, Asia-Pacific retail REITs were generally validated as a high-return/high-risk investment asset benchmarked against regional and the US stocks over the two sub-periods. This is inconsistent with risk-return attributes of the traditional listed property investment asset, which normally features low-return/low-risk profiles.

The inter-Asia-Pacific retail REIT correlation matrix from July 2006 to December 2018 is exhibited in **Table 7-10**. This comprises retail REITs in the USA, Japan, Australia and Singapore. The differences between pre-GFC (Panel A) and post-GFC (Panel B) are also highlighted. The pre-GFC (average $r = 0.51$) and post-GFC (0.52) Asia-Pacific retail investment strategies offered desirable portfolio diversification benefits for investors. Strong correlations between Japan and other retail REITs in the region (average $r = 0.61$) were observed pre-GFC. However, investors could achieve greater diversification benefits by adding the USA, Australia and Singapore (average $r = 0.40$) to their portfolio holdings. Post the GFC, the inclusion of Japan offered attractive portfolio diversification benefits (average $r = 0.38$) for investors. Japan and the USA had the lowest correlations ($r = 0.25$) in the retail REIT-based portfolio. However, the addition of Australia offered lesser portfolio diversification benefits for investors, since the correlation coefficients of Australia with Singapore and the USA were 0.77 and 0.67, respectively.

Figure 7-9: Risk and return profiles of Asia-Pacific retail REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

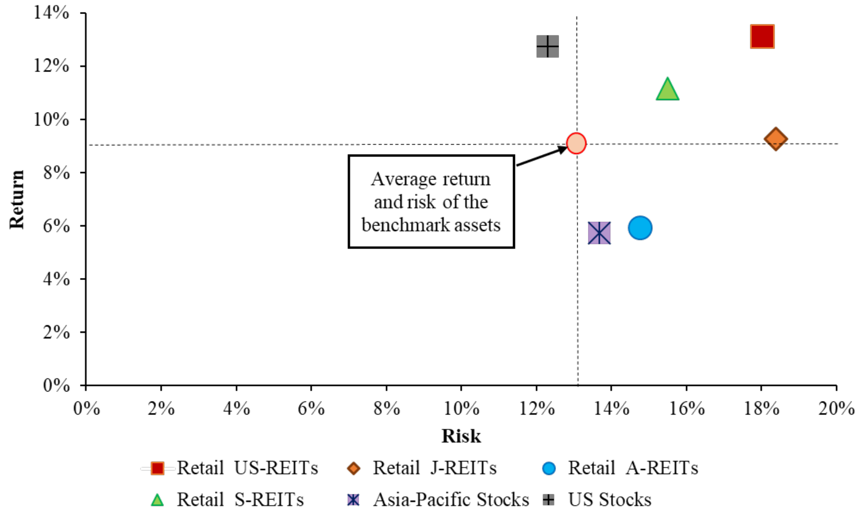


Table 7-10: Asia-Pacific retail REIT correlation analysis*

Panel A: Pre-GFC: July 2006–September 2007

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.73*	1.00		
Australia	0.49	0.59*	1.00	
Singapore	0.23*	0.51*	0.48*	1.00

Panel B: Post-GFC: July 2009–December 2018

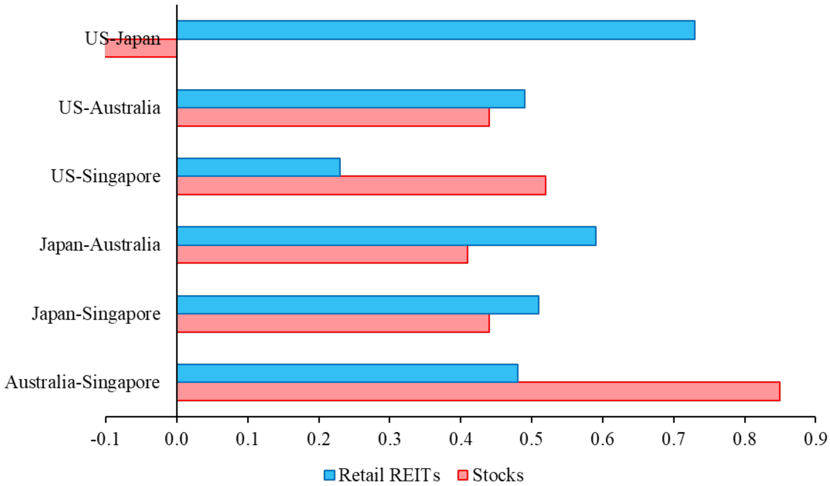
	US	Japan	Australia	Singapore
US	1.00			
Japan	0.25*	1.00		
Australia	0.67*	0.43*	1.00	
Singapore	0.54*	0.45*	0.77*	1.00

Note: *Significant correlation (p<5%)

Figure 7-10 compares geographic diversification benefits between inter-retail REIT and inter-stock investment perspectives over the sub-period timeframes, including the pre-GFC (Panel A) and post-GFC periods (Panel B). The post-GFC results generally show that a cross-country inter-retail REIT (average $r = 0.52$) investment strategy offered 14% more effective geographic diversifications compared with an inter-stock (average $r = 0.66$) investment framework. Prior to the GFC, a cross-country inter-retail REIT (average $r = 0.52$) investment strategy provided 9% less geographic diversifications compared with an inter-stock (average $r = 0.44$) investment framework, particularly via the diversification approaches of US-Japan ($r = 0.73$ vs $r = -0.13$), Japan-Australia ($r = 0.59$ vs $r = 0.41$), Japan-Singapore ($r = 0.51$ vs $r = 0.44$) and US-Australia ($r = 0.49$ vs $r = 0.44$).

Figure 7-10: Sub-period country correlation: retail REITs vs stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

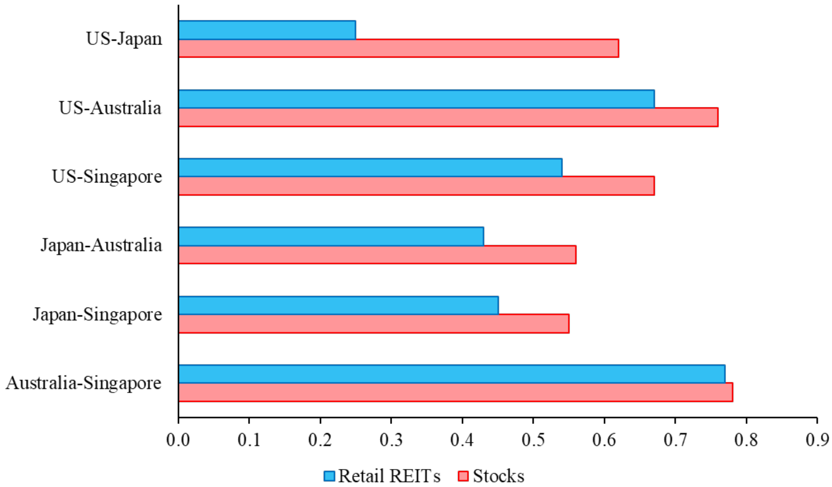


Figure 7-11 describes the optimal cross-country retail REIT-based portfolio analysis. The differential portfolio weights between the pre-GFC (Panel A) and post-GFC (Panel B) timeframes are also underlined. In Panel A, Singapore (average allocation = 63.9%) and Australia (35.5%) were prominently weighted in the retail REIT-based portfolio, while the USA (0.6%) only figured in a minor role in the retail REIT-based portfolio and Japan did not have any role. As the risk level heightened, Singapore complemented Australia across the entire risk-return band, particularly in the higher end. This can be clarified by the higher-return/higher-volatility of Singapore, which resulted in it being largely allocated at the upper-end of the optimised portfolio.

Panel B depicts the distinct patterns from Panel A. The overwhelming weights for the USA (67.7%) occurred across the entire risk-return range, particularly in the higher end. This can be clarified by the higher-return/higher-risk attributes of the USA. It progressively displaced the portfolio positions of Singapore (23.2%), Japan (6.3%) and Australia (2.8%) when the risk level heightened. Singapore and Japan mainly had roles at the lower end of the optimised portfolio, while Australia only showed at the start of the risk-return scale. Overall, the results suggest that Singapore was a viable portfolio enhancer over the two sub-periods, while the USA could enhance portfolio returns in the post-GFC context.

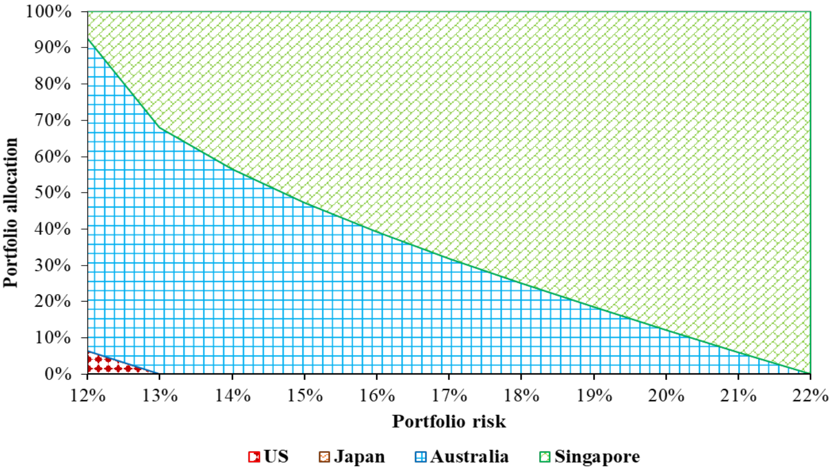
Figure 7-12 depicts the comparison of Asia-Pacific retail REIT-based efficient frontiers between pre- and post-GFC timeframes. As seen from the graph, the pre-GFC efficient frontier was above the post-GFC curve. This confirms that the pre-GFC efficient portfolio outperformed the post-GFC portfolio at each risk level. Additionally, the pre-GFC efficient frontier spanned a broader range of returns, from 32.49% p.a. to 59.12% p.a., and risk levels, from 12.38% to 21.53%. This was because Singapore and Australia injected higher returns and higher risk into the pre-GFC portfolio. On the other hand, the portfolio returns (from 9.4% p.a. to 13.10% p.a.) and risk (from 13.16% to 18.03%) of the post-GFC efficient frontier were limited.

In sum, unlike the traditional listed property investment asset, Asia-Pacific retail REITs exhibited the high-return/high-risk attributes over the full study period, as well as the two sub-periods. Additionally, investors seeking portfolio diversifications in the Asia-Pacific could achieve desirable portfolio diversification benefits by investing cross-country retail

REIT-based portfolios. The strong correlations of Australia with Singapore and the USA after the GFC were noteworthy for investment in a regional retail REIT-based portfolio. Last but not least, within the regional retail REIT-based portfolio, Singapore was the most significant portfolio enhancer for investors over the entire study period, with the USA an attractive investment option for investors seeking exposure to high-return/high-risk assets in the region in the post-GFC context.

Figure 7-11: Asia-Pacific retail REIT sub-period asset allocation diagram

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

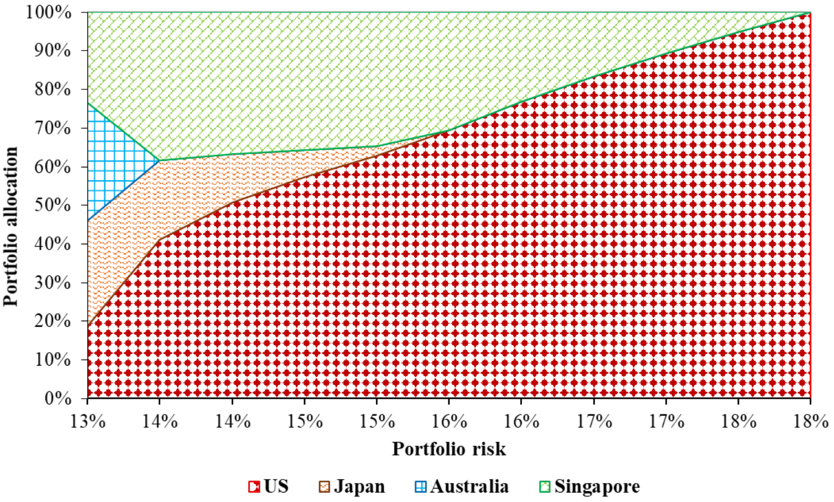
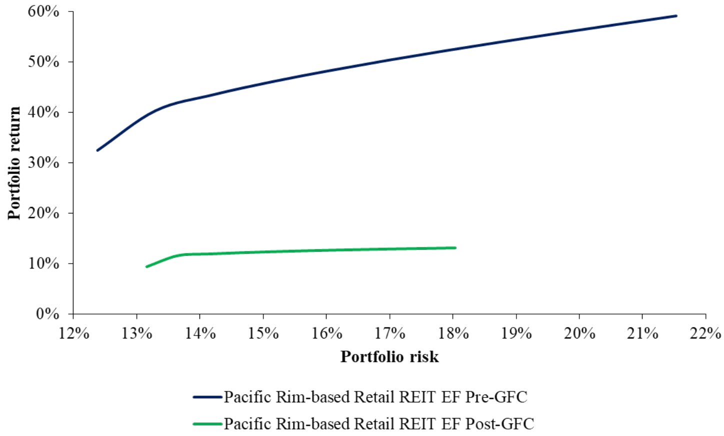


Figure 7-12: Asia-Pacific retail REIT-based efficient frontiers pre-GFC vs post-GFC



7.4 PERFORMANCE OF ASIA-PACIFIC INDUSTRIAL REIT-BASED PORTFOLIO

7.4.1 Risk-adjusted Performance Analysis

Table 7-11 assesses and compares the risk-adjusted performance for industrial REITs in the USA, Japan, Australia and Singapore from July 2006 to December 2018. Of the four industrial REIT markets, Singapore injected the highest average annual returns at 9.59% p.a., with Japan (8.84% p.a.), Australia (3.24% p.a.) and the USA (1.82% p.a.) trailing behind. In terms of the risk level, Singapore had the second-lowest exposure to risk (annual risk = 22.01%), surpassing Australia (26.05%) and the USA (38.72%). Japan had the lowest annual risk level at 21.85% in the regional industrial REIT markets over the study period. With the strongest average annual returns and the second-lowest annual risk, Singapore (the return/risk ratio = 0.44) was ranked as the best risk-adjusted performing industrial REIT market in the region. The poor annual returns and high volatility of the USA (0.05) made it the worst risk-adjusted performer. Japan (0.40) and Australia (0.12) were positioned between Singapore and the USA on a risk-adjusted return basis.

Table 7-11: Asia-Pacific industrial REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
US	1.82	38.72	0.05	4
Japan	8.84	21.85	0.40	2
Australia	3.24	26.05	0.12	3
Singapore	9.59	22.01	0.44	1

Note: *US dollars

7.4.2 Diversification Benefit Analysis

The inter-asset correlation matrix for industrial REITs across these four markets is displayed in **Table 7-12**. The most interesting observation is that a cross-country inter-Asia-Pacific industrial REIT investment strategy (average $r = 0.44$) would offer strong portfolio diversification benefits for investors seeking portfolio diversifications in the Asia-Pacific region. Japan was weakly correlated with the other industrial REIT markets in the region, such as the USA ($r = 0.19$), Australia ($r = 0.37$) and Singapore ($r = 0.47$). In contrast, Australia was weakly correlated with the other two industrial REITs, namely Singapore ($r = 0.69$) and the USA ($r = 0.56$). This indicates that Asia-Pacific industrial REIT investors could achieve higher portfolio diversification benefits by adding Japan rather than Australia to their investment portfolios over the full study timeframe.

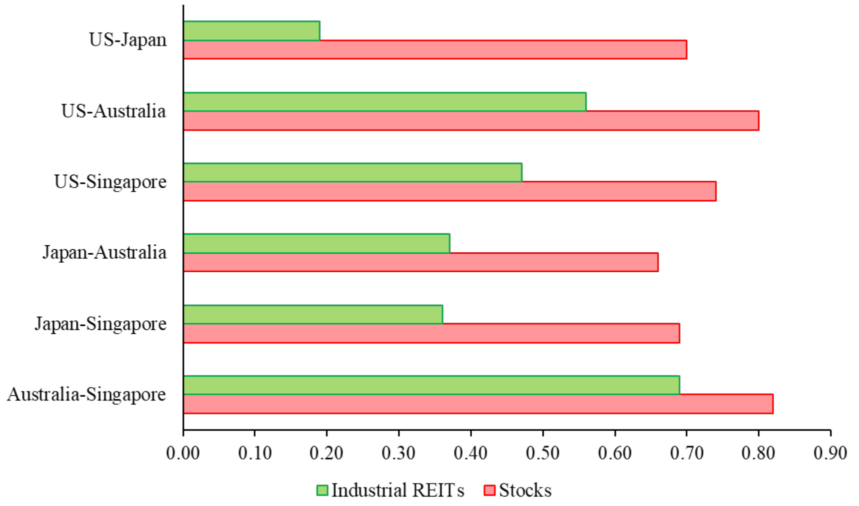
Table 7-12: Asia-Pacific industrial REIT correlation analysis*: July 2006–December 2018

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.19*	1.00		
Australia	0.56*	0.37*	1.00	
Singapore	0.47*	0.36*	0.69*	1.00

Note: *Significant correlation (p<5%)

Figure 7-13 shows the comparisons of geographic diversification benefits between inter-industrial REIT and inter-stock investment perspectives over the entire study period. International investors seeking portfolio diversifications in the Asia-Pacific region and the US investment context could attain 30% higher geographic diversification benefits by using a cross-country inter-industrial REIT (average $r = 0.44$) investment strategy compared with a cross-country inter-stock investment strategy (average $r = 0.74$). In particular, within a cross-country inter-industrial REIT diversification strategy, a US-Japan diversification approach ($r = 0.19$) offered stronger geographic diversification benefits Japan-Singapore ($r = 0.36$), Japan-Australia ($r = 0.37$), US-Singapore ($r = 0.47$), US-Australia ($r = 0.56$) or Australia Singapore ($r = 0.69$) approaches.

Figure 7-13: Country correlation: industrial REITs vs stocks: July 2006–December 2018



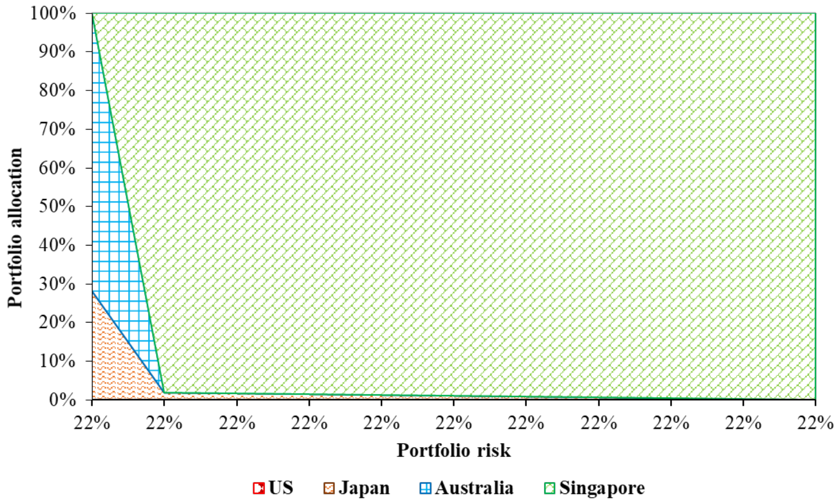
7.4.3 Portfolio Analysis

Table 7-13 and **Figure 7-14** reveal the estimated optimal portfolio allocations for the USA, Japan, Australia and Singapore in a cross-country industrial REIT-based portfolio from July 2006 to December 2018 and the corresponding portfolio returns and risk levels. The optimal cross-country industrial REIT-based portfolio annualised returns ranged from 4.82% p.a. to 9.59% p.a., with the portfolio standard deviations between 21.73% and 22.01%. Singapore (average allocation = 90.1%) was the predominant enhancer of portfolio returns across the entire risk-return range, reaching a maximum level of 100%. This was driven by its having the highest annual returns and lowest annual volatility of the four industrial REIT markets. The other two industrial REITs played only minor roles in the lower end of the risk-return range, namely Australia (6.5%) and Japan (3.4%). The USA did not have any role in the regional industrial REIT-based portfolio, due to having the poorest average annual returns and the highest annual risk level of the four REITs.

Table 7-13: Asia-Pacific industrial REIT asset allocation: July 2006–December 2018

USA	Japan	Australia	Singapore	Portfolio return	Portfolio risk
0.0%	28.3%	71.7%	0.0%	4.82%	21.73%
0.0%	1.8%	0.0%	98.2%	9.58%	21.75%
0.0%	1.6%	0.0%	98.4%	9.58%	21.78%
0.0%	1.4%	0.0%	98.6%	9.58%	21.81%
0.0%	1.2%	0.0%	98.8%	9.58%	21.84%
0.0%	1.0%	0.0%	99.0%	9.58%	21.87%
0.0%	0.8%	0.0%	99.2%	9.58%	21.90%
0.0%	0.6%	0.0%	99.4%	9.59%	21.93%
0.0%	0.4%	0.0%	99.6%	9.59%	21.95%
0.0%	0.2%	0.0%	99.8%	9.59%	21.98%
0.0%	0.0%	0.0%	100.0%	9.59%	22.01%

Figure 7-14: Asia-Pacific industrial REIT asset allocation diagram: July 2006–December 2018



7.4.4 Sub-period Analysis

Table 7-14 shows risk-adjusted returns for industrial REITs in the USA, Japan, Australia and Singapore over the pre-GFC (Panel A) and post-GFC (Panel B) sub-periods. Prior to the GFC, Singapore (45.56% p.a.) provided superior average annualised returns to Australia (33.12% p.a.), the USA (15.39% p.a.) and Japan (6.44% p.a.). In terms of annual risk level, Japan gained exposure to the highest risk level at 30.11%, with its poorest annualised returns. It was riskier than Singapore (annual risk = 26.00%), the USA (18.41%) and Australia (14.67%). With the second-highest annualised returns and the lowest annual risk, Australia (return/risk ratio = 2.26) was the best performer, exceeding Singapore (1.75), the USA (0.84) and Japan (0.21) on a risk-adjusted return basis. Post the GFC, the USA (16.57% p.a.) posted the highest annual returns among the four industrial REITs in the region. It overtook Australia (14.16% p.a.), Japan (12.71% p.a.) and Singapore (12.00% p.a.). The risk level for the USA (21.42%) was the highest among all industrial REITs, followed by Japan (18.52%), Australia (18.28%) and Singapore (15.53%). On a risk-adjusted return basis, Australia (0.77) maintained its first place in the risk-adjusted return ranking from the pre-GFC context. Despite posting the lowest average annual returns, Singapore (0.77) was ranked third place owing to having the lowest annual volatility. It was just surpassed by Australia and the USA (0.77), but superior to Japan (0.69).

Table 7-14: Asia-Pacific industrial REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
US	15.39	18.41	0.84	3
Japan	6.44	30.11	0.21	4
Australia	33.12	14.67	2.26	1
Singapore	45.56	26.00	1.75	2
Panel B: Post-GFC: July 2009–December 2018				
US	16.57	21.42	0.77	2
Japan	12.71	18.52	0.69	4
Australia	14.16	18.28	0.77	1
Singapore	12.00	15.53	0.77	3

Note: *US dollars

Figure 7-15 plots the risk versus returns of industrial REITs in the USA, Japan, Australia and Singapore benchmarked against Asia-Pacific stocks and US stocks in the pre-GFC (Panel A) and post-GFC timeframes (Panel B). Before the GFC, two of four industrial REITs in the region, namely Singapore and Australia, were positioned in the upper-right section of the risk-return diagram. This is the normal quadrant for investment with higher risk-return trade-offs. In contrast, the weak average annual returns (6.44% p.a.) and extreme volatility (average annual risk = 30.11%) of Japan saw it placed in the lower-right quadrant, as is the USA. In other words, these two industrial REIT markets were unable to generate higher returns but exposed investors to high volatility.

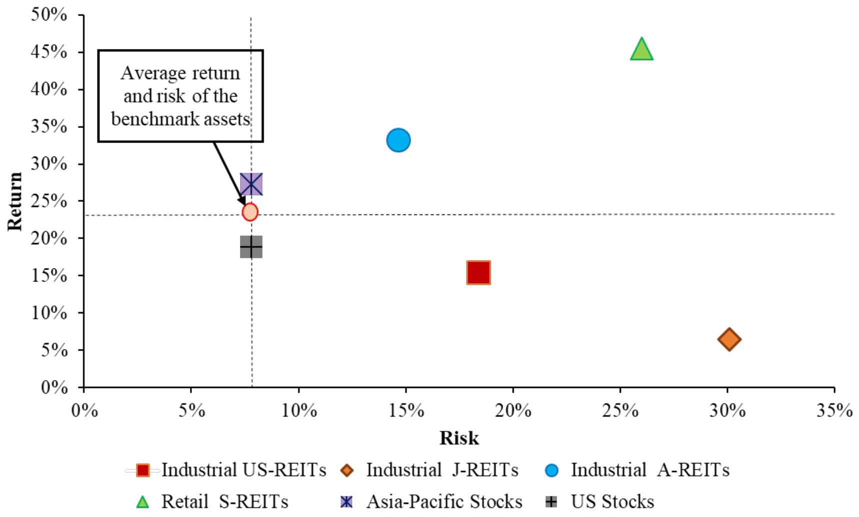
After the GFC, the higher returns of all industrial REITs in the region can be observed in the upper-right corner of the scatter plot, which is the higher-return/higher-risk quadrant for investors. This reflects the more optimistic investment characteristics of the industrial REIT markets in the region. This is inconsistent with expected risk-return profiles of a listed property investment vehicle, which is traditionally characterised by low-return/low-risk attributes.

Table 7-15 demonstrates the results of the analysis of the correlations between the four industrial REITs in the Asia-Pacific, covering the pre-GFC (Panel A) and post-GFC (Panel B) periods. Both the pre-GFC (average $r = 0.30$) and post-GFC (average $r = 0.50$) industrial REIT investment strategies provided attractive portfolio diversification benefits for investors. Portfolio diversification benefits of the post-GFC strategy slipped from the pre-GFC level but were still desirable for investors seeking portfolio diversifications in the Asia-Pacific region. Prior to the GFC, it is noteworthy that the USA was negatively correlated with Singapore ($r = -0.05$). This implies that investors could achieve the greatest portfolio diversification benefits by adding these two assets to their regional industrial REIT-based portfolio. The USA was weakly correlated with the other industrial REITs in the region, namely Japan ($r = 0.13$) and Australia ($r = 0.48$). Japan had a weak correlation with the other two industrial REITs in the region, namely Australia ($r = 0.26$) and Singapore ($r = 0.29$). Conversely, Australia had marginally strong correlations with Singapore ($r = 0.66$).

Post-GFC, Japan would be the priority investment asset for investors managing portfolio diversifications in the regional industrial REIT-based portfolio, since it was weakly correlated with the other three industrial REITs, namely the USA ($r = 0.30$), Australia ($r = 0.43$) and Singapore ($r = 0.48$). In contrast, Australia had strong correlations with Singapore ($r = 0.68$) and the USA (0.66). This suggests that geographical diversifications in a cross-country inter-Asia-Pacific industrial REIT investment strategy are achievable if careful selections of individual industrial REIT markets in the region are made to achieve maximum diversification benefits.

Figure 7-15: Risk and return profiles of Asia-Pacific industrial REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

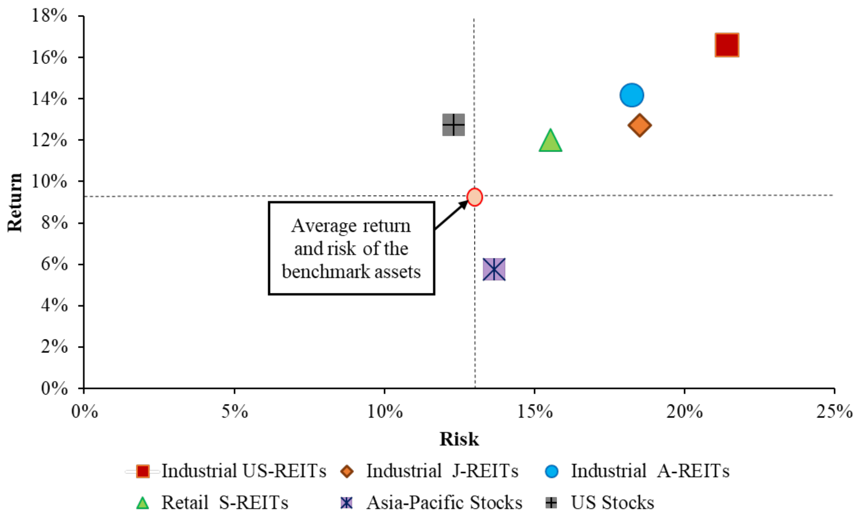


Figure 7-16 compares geographic diversification benefits between inter-industrial REITs and inter-stock investment perspectives over the pre-GFC (Panel A) and post-GFC periods (Panel B). The results generally show that a cross-country inter-industrial REIT (average $r = 0.30$) investment strategy offered 12% more effective geographic diversifications than an inter-stock (average $r = 0.42$) investment framework in the pre-GFC context. Post-GFC, a cross-country inter-industrial REIT diversification strategy (average $r = 0.50$) provided 16% higher geographic diversifications than an inter-stock (average $r = 0.66$) investment framework. The exceptions were a pre-GFC inter-industrial REIT investment strategy via the diversification approaches of US-Japan ($r = 0.13$) and US-Australia ($r = 0.48$), which offered 26% and 4% less geographic diversifications

respectively than a cross-country inter-stock diversification strategy through the same channels ($r = -0.13$; $r = 0.44$).

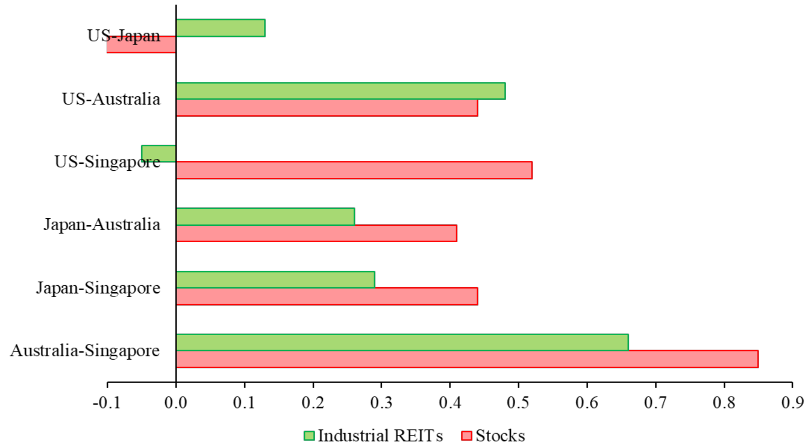
Table 7-15: Asia-Pacific industrial REIT correlation analysis*

Panel A: Pre-GFC: July 2006–September 2007	US	Japan	Australia	Singapore
US	1.00			
Japan	0.13	1.00		
Australia	0.48*	0.26*	1.00	
Singapore	-0.05	0.29*	0.66*	1.00
Panel B: Post-GFC: July 2009–December 2018	**US**	**Japan**	**Australia**	**Singapore**
US	1.00			
Japan	0.30*	1.00		
Australia	0.66*	0.43*	1.00	
Singapore	0.43*	0.48*	0.68*	1.00

Note: *Significant correlation (p<5%)

Figure 7-16: Sub-period country correlation: industrial REITs vs stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

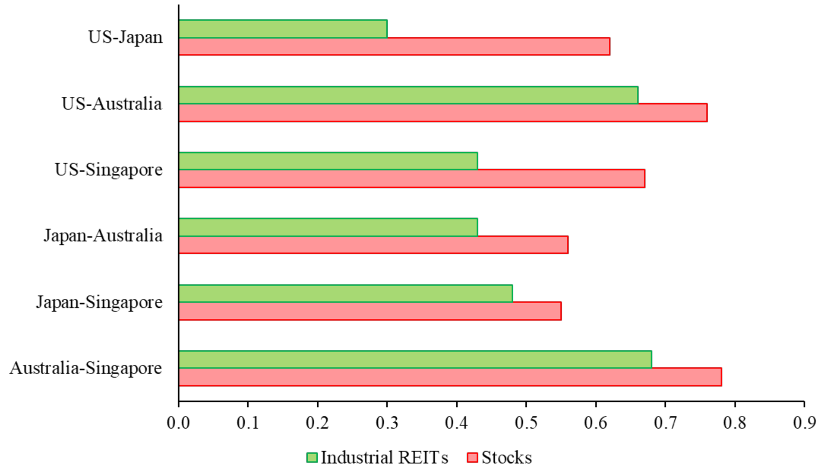


Figure 7-17 illustrates the portfolio compositions of the optimal Asia-Pacific industrial REIT-based portfolio over two sub-periods, the pre-GFC (Panel A) and post-GFC timeframes (Panel B). The regional industrial REIT-based portfolio comprises industrial REITs across the USA, Japan, Australia and Singapore. Before the GFC, Australia (average allocation = 41.7%) was largely concentrated in the lower end of the risk-return band, as it posted the lowest annual risk level and the second-highest annual returns among four industrial REITs. The USA (3.0%) and Japan (0.9%) had minor roles at the start of the risk-return range. Singapore (54.4%) had a prominent role in the regional industrial REIT-based portfolio. At the highest risk-return level, the optimal portfolio allocation was 100% for Singapore, and the portfolio delivered an average return of 45.56% p.a., with the annual risk level at 26.00%.

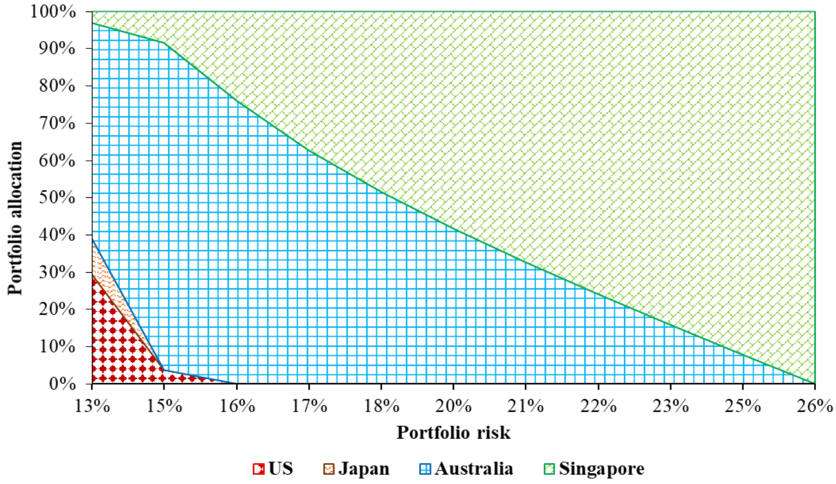
After the GFC, the risk-return trade-offs of Australia, the USA and Singapore were comparable with one another. The USA (68.7%) dominated across the whole risk-return scale, reaching a maximum level at 100% in the higher end of the risk-return scale. The USA complemented the portfolio allocations of Japan (17.1%), Australia (8.9%) and Singapore (5.3%) when the risk level soared. This can be clarified by the high-return/high-risk attributes of the USA. Due to strong correlations with the USA (r = 0.68), Australia was largely overshadowed by the USA in the lower end of the risk-return diagram. Singapore was mostly replaced by Australia, since it was strongly correlated with Australia (r = 0.66). With the weak correlations with the other three industrial REITs in the region, Japan figured across the broad risk-return spectrum. As each industrial REIT market in the region featured lower-return/lower-risk attributes in the post-GFC context, the average returns of the post-GFC portfolio fell by 23.66% p.a. in comparison with the pre-GFC level, with the risk level improving by 1.79%.

Figure 7-18 exhibits the efficient frontiers of the Asia-Pacific industrial REIT-based portfolios between the pre-GFC and post-GFC periods. As can be seen, the pre-GFC efficient frontier outperformed the post-GFC curve. This is evident from the wider range and upward shift of the pre-GFC curve on the x- and y-axes compared with the post-GFC curve. Specifically, the pre-GFC regional industrial REIT-based portfolio was higher than the post-GFC curve at every point of the risk-return band. The results confirm the pre-GFC efficient frontier was the better portfolio return enhancer than the post-GFC curve.

Overall, the results imply that Asia-Pacific industrial REITs were high-return/high-risk investment assets over the full study period. The regional industrial REIT-based portfolio offered attractive portfolio diversification benefits for investors seeking portfolio diversifications in the Asia-Pacific, particularly including Japan. Since Australia was strongly correlated with the other three industrial REIT markets in the region, investors are advised to be conservative in investing in the regional industrial REIT-based portfolio. Within the regional industrial REIT-based portfolio, Singapore was the most attractive portfolio enhancer over the entire study period, while the USA showed strong risk-return attributes in the post-GFC investment context.

Figure 7-17: Asia-Pacific industrial REIT sub-period asset allocation diagram

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

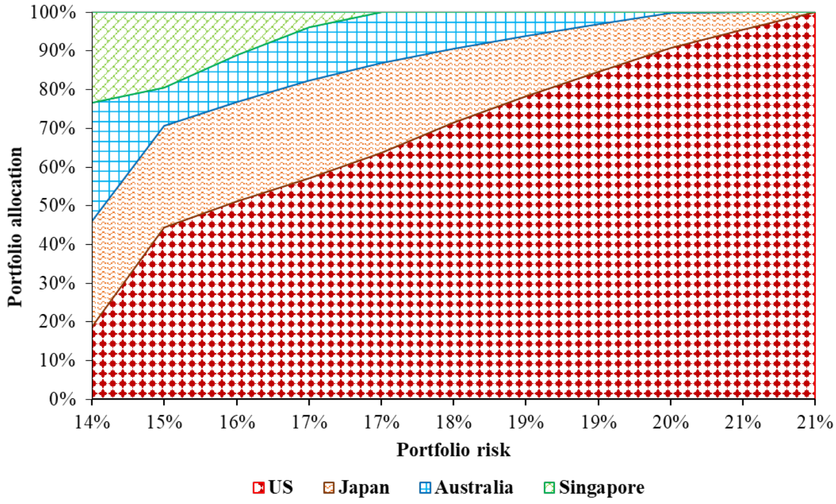
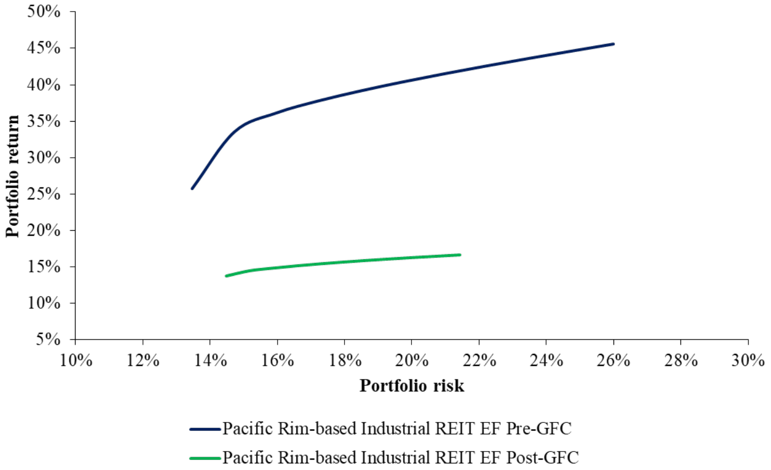


Figure 7-18 Asia-Pacific industrial REIT efficient frontiers pre-GFC vs post-GFC



7.5 PERFORMANCE OF ASIA-PACIFIC RESIDENTIAL REIT-BASED PORTFOLIO

7.5.1 Risk-adjusted Performance Analysis

Table 7-16 summarises the risk-adjusted performance of residential REITs in the USA, Japan, Australia and Singapore from July 2006 to December 2018. With an average return of 8.07% p.a., the USA was the best performer among the four, exceeding Singapore (7.82% p.a.), Japan (6.81% p.a.) and Australia (2.67% p.a.) over the full study period. The annual volatility for Australia (annual risk = 39.58%) was the highest among all residential REIT markets in the region, ahead of Singapore (26.71%), the USA (23.04%) and Japan (22.10%) over the entire study period. With the highest annual returns and the second-lowest annual risk among these four residential REITs in the region, the USA (return/risk ratio = 0.35) was the best risk-adjusted performer. Japan and Singapore delivered competitive risk-return trade-offs with a return/risk ratio of 0.31 and 0.29, respectively. In contrast, Australia (0.07) offered the poorest average annual returns and the highest risk level in the region, greatly impairing its risk-adjusted performance and relegating it to the last place in the ranking over the full study timeframe.

Table 7-16: Asia-Pacific residential REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
US	8.07	23.04	0.35	1
Japan	6.81	22.10	0.31	2
Australia	2.67	39.58	0.07	4
Singapore	7.82	26.71	0.29	3

Note: *US dollars

7.5.2 Diversification Benefit Analysis

Table 7-17 presents the results of the analysis on the correlations between these four residential markets in the region from July 2006 to December 2018. A cross-country inter-Asia-Pacific residential REIT (average $r = 0.55$) investment strategy offered moderately strong portfolio diversification benefits for investors. Notably, the correlation coefficients of Japan with Australia and Singapore were 0.62 and 0.58, respectively. Over the same period, Australia was strongly correlated with Singapore ($r = 0.67$). In contrast, the USA was weakly correlated with the other three residential REITs – Japan ($r = 0.45$), Singapore ($r = 0.45$) and Australia ($r = 0.50$).

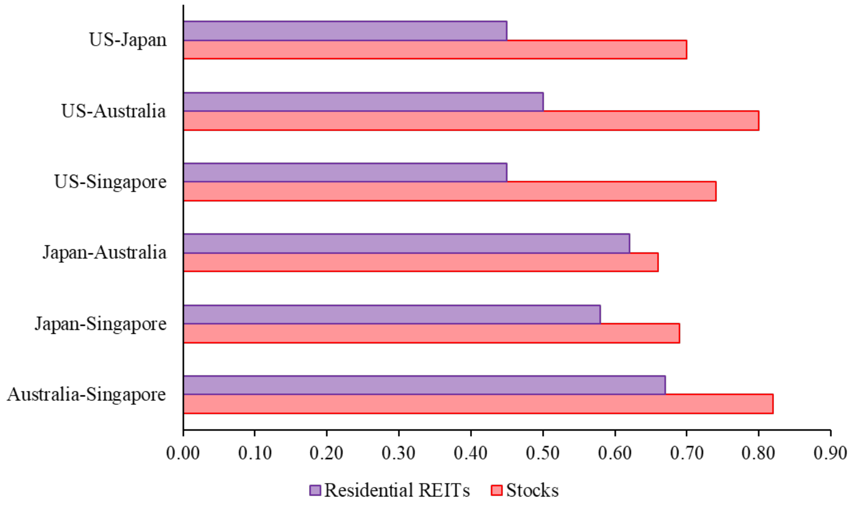
Table 7-17: Asia-Pacific residential REIT correlation analysis*: July 2006–December 2018

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.45*	1.00		
Australia	0.50*	0.62*	1.00	
Singapore	0.45*	0.58*	0.67*	1.00

Note: *Significant correlation (p<5%)

Figure 7-19 presents the comparison of geographic diversification benefits between inter-residential REIT and inter-stock investments over the full study period. International investors seeking portfolio diversification in the Asia-Pacific and US investment contexts could achieve 19% more effective geographic diversification using a cross-country inter-residential REIT (average $r = 0.55$) investment strategy compared with a cross-country inter-stock strategy (average $r = 0.74$). Within a cross-country inter-residential REIT diversification strategy, a US-Japan diversification approach ($r = 0.45$) offered stronger geographic diversification benefits than US-Singapore ($r = 0.45$), US-Australia ($r = 0.50$), Japan-Singapore ($r = 0.58$), Japan-Australia ($r = 0.62$) or Australia-Singapore (0.67).

Figure 7-19: Country correlation: residential REITs vs stocks: July 2006–December 2018



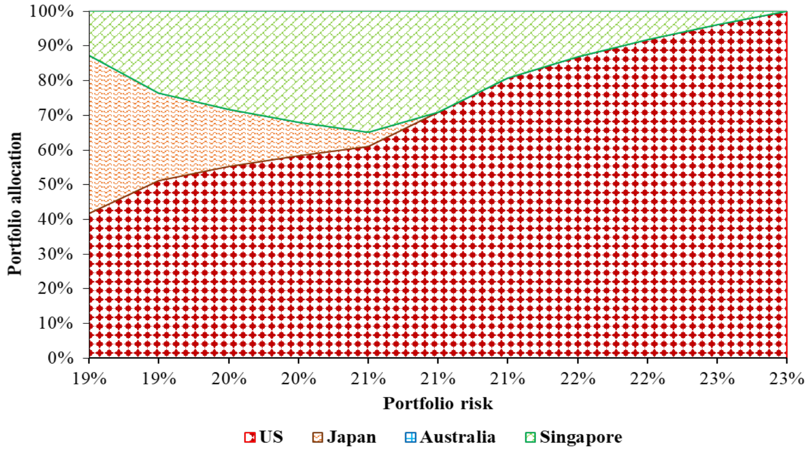
7.5.3 Portfolio Analysis

Table 7-18 lists the portfolio compositions of the optimal portfolio of cross-country residential REITs across the USA, Japan, Australia and Singapore, along with the portfolio annual returns and risk from July 2006 to December 2018. **Figure 7-20** is an asset allocation diagram of the optimal regional cross-country residential REIT-based portfolio. It articulates roles of cross-country residential REITs across the risk-return band over the same period. The USA were constituents at almost every risk-return scale of the optimised portfolio, with a dominant portfolio allocation evident from the low-to-high range, and recorded an average portfolio allocation of 72.2%. Singapore shows a similar pattern, reaching a comparable minor average portfolio composition of 18.6%. Japan only featured in the lower end of the risk-return range, due to its having lowest annual risk level in the regional residential portfolio, achieving a negligible role of 9.2%, while Australia did not have any role across the broad risk-return band. In terms of annual portfolio returns and risk, the registered portfolio returns ranged from 7.46% p.a. to 8.07% p.a., with the annual risk level ranging from 19.02% to 23.04%.

Table 7-18: Asia-Pacific residential REIT asset allocation: July 2006–December 2018

US	Japan	Australia	Singapore	Portfolio return	Portfolio risk
41.8%	45.6%	0.0%	12.6%	7.46%	19.02%
51.2%	25.1%	0.0%	23.6%	7.69%	19.42%
55.2%	16.5%	0.0%	28.3%	7.79%	19.83%
58.4%	9.8%	0.0%	31.9%	7.87%	20.23%
61.1%	4.0%	0.0%	34.9%	7.93%	20.63%
70.8%	0.0%	0.0%	29.2%	8.00%	21.03%
80.8%	0.0%	0.0%	19.2%	8.02%	21.43%
86.9%	0.0%	0.0%	13.1%	8.04%	21.84%
91.9%	0.0%	0.0%	8.1%	8.05%	22.24%
96.2%	0.0%	0.0%	3.8%	8.06%	22.64%
100.0%	0.0%	0.0%	0.0%	8.07%	23.04%

Figure 7-20: Asia-Pacific residential REIT asset allocation diagram: July 2006–December 2018



7.5.4 Sub-period Analysis

Table 7-19 tabulates the empirical results of the risk-return performance analysis on cross-country residential REITs across the USA, Japan, Australia and Singapore over the pre-GFC (Panel A) and post-GFC (Panel B) periods. Average annual returns for the four residential REITs were extremely volatile over two sub-period timeframes. Prior to the GFC, Singapore and Australia offered attractive average annual returns at more than 40%, registering 68.78% p.a. and 44.88% p.a., respectively. This was higher than Japan (9.37% p.a.) and the USA (1.39% p.a.). For annual volatility, Singapore (annual risk = 25.86%) ranked higher than the USA (21.82%), Japan (16.19%) and Australia (14.04%). With the second-highest annual returns and lowest annual risk, Australia (return/risk ratio = 3.20) was the best risk-adjusted performer. With the highest annual returns, Singapore (2.66) had lesser competitive risk-return trade-offs than Australia, placing it second in the ranking. It was followed by Japan (0.58) in third place. With the lowest average annual returns and the highest risk level, the USA (0.06) greatly weakened its risk-adjusted performance and occupied the last place in the ranking over the full study timeframe.

Post to the GFC, the resurgence in the USA contributed the highest average annual returns at 17.49% p.a., followed by Japan (12.43% p.a.), Australia (11.77% p.a.) and Singapore (9.03% p.a.). In terms of the annual risk level, the USA (annual risk = 17.60%) was higher risk than Singapore (16.37%) and Japan (16.35%), while Australia (22.38%) was the riskiest investment asset among the four residential REITs. On a risk-return trade-offs basis, the USA was the most competitive investment asset with a return/risk ratio of 0.99. It was followed by Japan and Singapore, with return/risk ratios of 0.76 and 0.55, respectively. With the highest annual volatility, Australia held the last place in the ranking, with a return/risk ratio of 0.53.

Table 7-19: Asia-Pacific residential REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
US	1.39	21.82	0.06	4
Japan	9.37	16.19	0.58	3
Australia	44.88	14.04	3.20	1
Singapore	68.78	25.86	2.66	2
Panel B: Post-GFC: July 2009–December 2018				
US	17.49	17.60	0.99	1
Japan	12.43	16.35	0.76	2
Australia	11.77	22.38	0.53	4
Singapore	9.03	16.37	0.55	3

Note: *US dollars

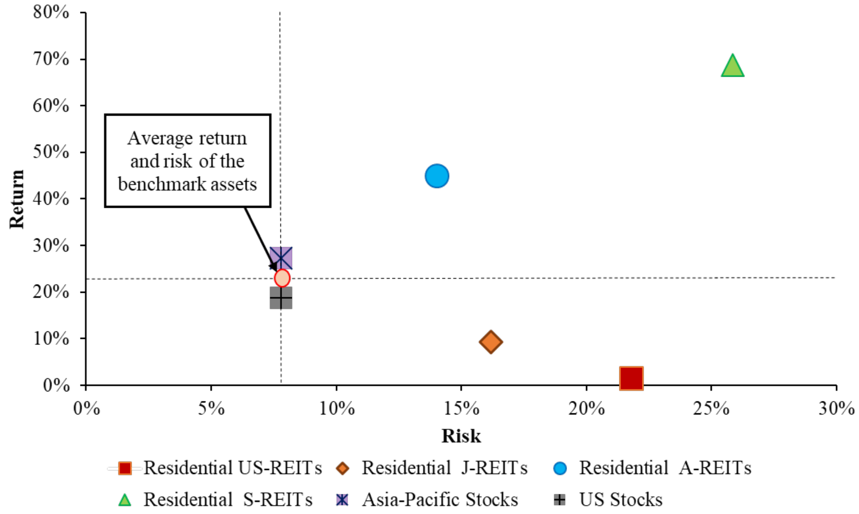
To offer a deeper understanding of the risk-adjusted analysis of residential REITs across the USA, Japan, Australia and Singapore, the risk-return figures were plotted in a scatter diagram to enable peer comparison benchmarked against regional and US stocks over the pre-GFC (Panel A) and post-GFC (Panel B) periods, as shown in **Figure 7-21**. Prior to the GFC, Singapore and Australia were placed in the upper-right quadrant of the scatter diagram. This signified high annual returns relative to high exposure to volatility for these two residential REIT markets. In contrast, Japan and the USA were positioned in the lower-right quadrant, which represents an investment with high-risk/low-return attributes.

In other words, these two residential REIT markets were unable to generate returns and exposed investors to high volatility.

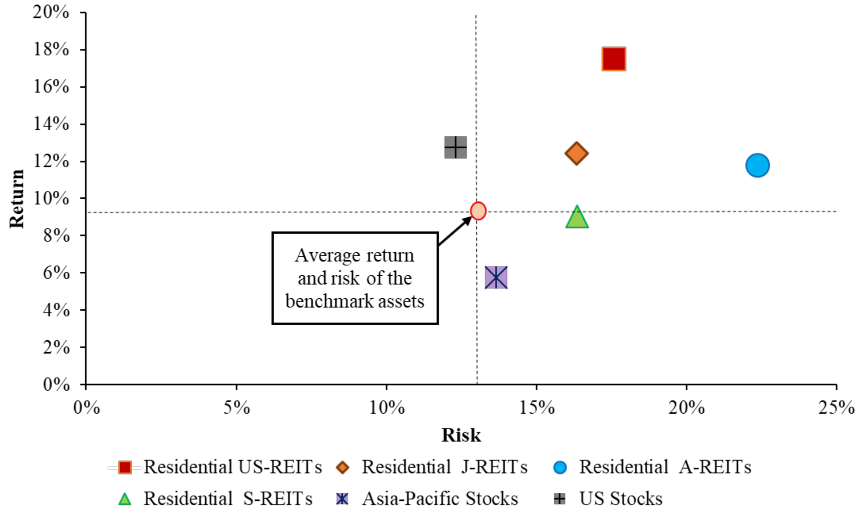
Post to the GFC, all four residential REITs in the region were generally placed in the upper-right section of the risk-return diagram. This is the normal quadrant for investments with higher risk-return trade-offs coupled with high volatility. Singapore was plotted on the borderline between the upper- and lower-right quadrant, indicating that it offered lower risk-return trade-offs in comparison with the other three residential REITs. Generally, the high-return/high-risk attributes of these four residential REITs are incompatible with that of the traditional listed property investment channel.

Figure 7-21: Risk and return profiles of Asia-Pacific residential REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018



The cross-country inter-Asia-Pacific residential REITs correlation matrix over the pre-GFC (Panel A) and post-GFC (Panel B) periods are detailed in **Table 7-20**. These include residential REIT markets in the USA, Japan, Australia and Singapore. Both the pre-GFC (average $r = 0.20$) and post-GFC (average $r = 0.42$) Asia-Pacific residential REIT investment strategies offered appealing portfolio diversification benefits for investors, despite the post-GFC Asia-Pacific residential REIT investment strategy sliding from the pre-GFC level. Before the GFC, it is noteworthy that the USA was negatively and weakly correlated with the other two residential REITs in the region, Australia ($r = -0.13$) and Singapore ($r = -0.10$). It also had a weak correlation with Japan ($r = 0.23$). The other three residential REIT markets had comparable diversification benefits with one another. This placed the USA as the best portfolio diversifier in the pre-GFC Asia-Pacific residential investment strategy.

After the GFC, the USA was still the priority investment asset for investors seeking portfolio diversifications in the regional residential REIT-based portfolio, since it was moderately correlated with the other three – Japan ($r = 0.24$), Singapore ($r = 0.36$) and Australia ($r = 0.49$). Investors should be aware of including Australia and Singapore in the regional residential REIT-based portfolio, as they had strong correlations ($r = 0.63$). This implies that geographical diversifications in a cross-country inter-Asia-Pacific residential REIT investment strategy are possible with a reasonable selection of individual residential REIT markets in the region.

Table 7-20: Asia-Pacific residential REIT correlation analysis*

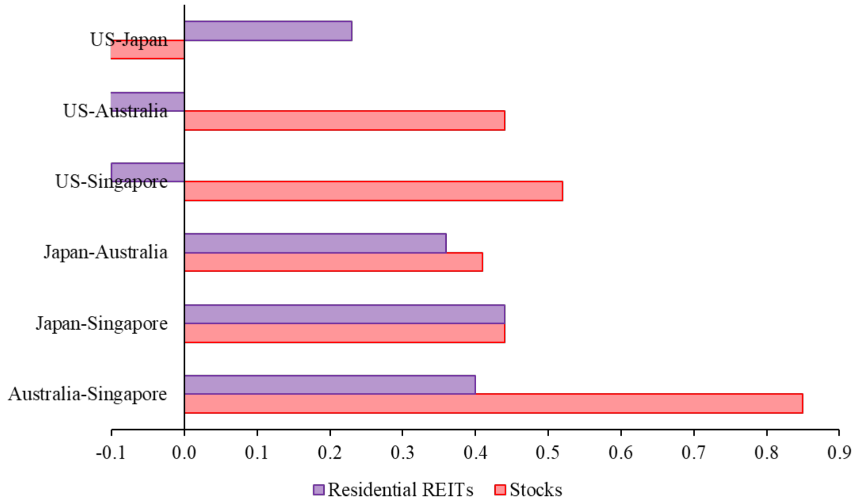
Panel A: Pre-GFC: July 2006–September 2007				
	US	Japan	Australia	Singapore
US	1.00			
Japan	0.23	1.00		
Australia	-0.13	0.36*	1.00	
Singapore	-0.10	0.44*	0.40*	1.00
Panel B: Post-GFC: July 2009–December 2018				
	US	Japan	Australia	Singapore
US	1.00			
Japan	0.24*	1.00		
Australia	0.49*	0.40*	1.00	
Singapore	0.36*	0.40*	0.63*	1.00

Note: *Significant correlation (p<5%)

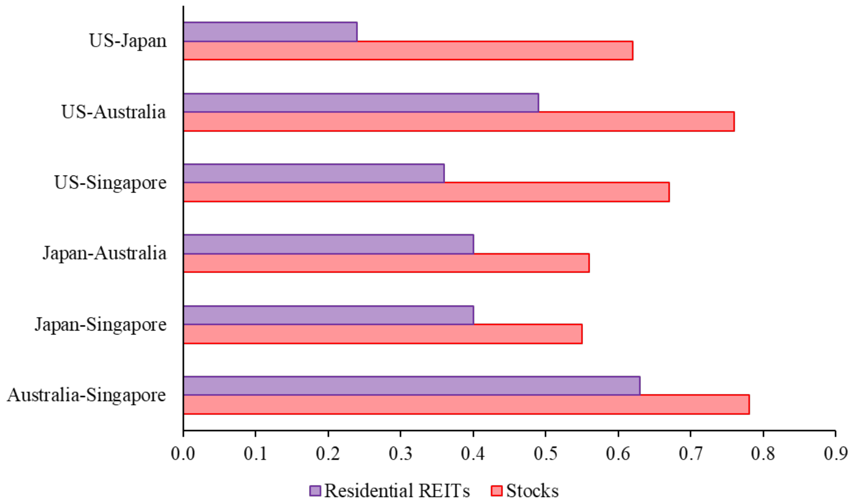
Figure 7-22 illustrates the comparisons of geographic diversification benefits between inter-residential REIT and inter-stock investment perspectives over the sub-period timeframes, including the pre-GFC (Panel A) and post-GFC periods (Panel B).

Figure 7-22: Sub-period country correlation: residential REITs vs stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018



The sub-period analysis shows that a cross-country inter-residential (average $r = 0.20$) REIT investment strategy offered 22% more effective geographic diversifications compared with an inter-stock (average $r = 0.42$) investment framework in the pre-GFC timeframes. Similarly, a cross-country inter-residential (average $r = 0.42$) REIT diversification strategy offered 24% higher geographic diversifications compared with an inter-stock (average $r = 0.66$) diversification strategy post to the GFC. Within a cross-country inter-residential REIT investment strategy, investors could obtain attractive geographic diversification benefits in the pre-GFC investment context by using the diversification approaches of US-Australia ($r = -0.13$) and US-Singapore ($r = -0.10$). Post to the GFC, investors could receive the highest geographic diversification benefits through a US-Japan approach ($r = 0.24$), followed by US-Singapore ($r = 0.36$), Japan-Australia ($r = 0.40$), Japan-Singapore ($r = 0.40$) and US-Australia ($r = 0.49$). However, an Australia-Singapore approach (0.63) within a cross-country inter-residential REIT investment strategy offered unattractive geographic diversifications for investors seeking portfolio diversifications in the region.

Figure 7-23 is an asset allocation diagram of the optimal cross-country inter-Asia-Pacific residential REIT-based portfolio, comprising residential REITs across the USA, Japan, Australia and Singapore. It depicts the roles of individual residential REIT markets in the region across the risk-return band over two sub-periods, including the pre-GFC (Panel A) and post-GFC (Panel B) timeframes. In the pre-GFC investment context, Singapore (average allocation = 55.8%) played the main role across the whole risk-return range. In particular, it complemented Australia (38.5%), the USA (4.1%) and Japan (1.5%) in the higher end of the risk-return scale when the risk level heightened, achieving a maximum level at 100% at the highest risk-return level. This was driven by Singapore having the highest annual returns prior to the GFC. Despite offering the best risk-return trade-offs, Australia featured less prominently across the entire risk-return range than Singapore because its average annual returns were 1.5 times less than those of Singapore. On the other hand, the USA and Japan played negligible roles at the start of the risk-return band due to their comparatively weaker average annual returns.

In the post-GFC investment context, the USA (81.1%) was dominant across the broad risk-return scale, reaching a maximum level at the highest risk-return level. As clearly seen in the diagram, it displaced Japan (14.0%), Australia (2.8%) and Singapore (2.1%) in the lower end of the risk-return range, since it was the best performer on a risk-return trade-off basis. Japan outweighed the portfolio allocations of Australia and Singapore at the start of the risk-return scale and enlarged its portfolio compositions when the risk level increase, but was gradually complemented by the USA. The portfolio returns of the optimal post-GFC residential REIT-based portfolio ranged from 12.39% p.a. to 17.49%

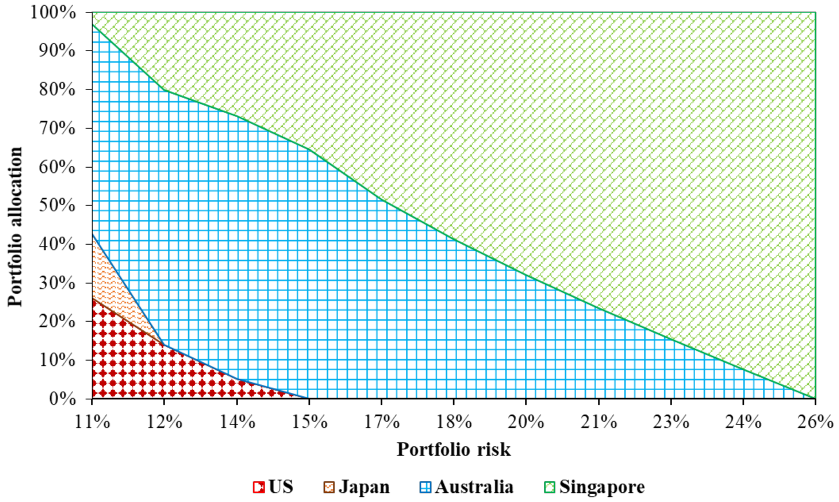
p.a., with the portfolio standard deviations from 14.21% to 17.60%. Compared with the pre-GFC level, portfolio average returns and risk shrank by 39.44% p.a. and 2.39%, respectively.

The efficient frontiers of the Asia-Pacific residential REIT-based portfolio over two sub-periods are exhibited in **Figure 7-24**. It can be clearly identified that the pre-GFC curve was higher and wider than the post-GFC curve at each point of the risk-return spectrum. The pre-GFC efficient frontier returns were up from 28.38% p.a. to 68.78% p.a., and the risk level was from 10.72% to 25.86%. This confirms that the pre-GFC portfolio delivered substantial growth of the efficient frontier, and can be accepted by both risk-averse and risk-taking investors.

Overall, Asia-Pacific residential REITs demonstrated high-return/high-risk attributes over the full study period, which is in contrast with the traditional listed property investment asset. The cross-country inter-Asia-Pacific residential REIT investment strategy offered the appealing portfolio diversification benefits for investors, particularly for the USA as the best portfolio diversifier in the region. Within the regional residential REIT-based portfolio, the USA was the strongest portfolio return enhancer in the post-GFC context, while Singapore was the best in the pre-GFC context.

Figure 7-23: Asia-Pacific residential REIT sub-period asset allocation diagram

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

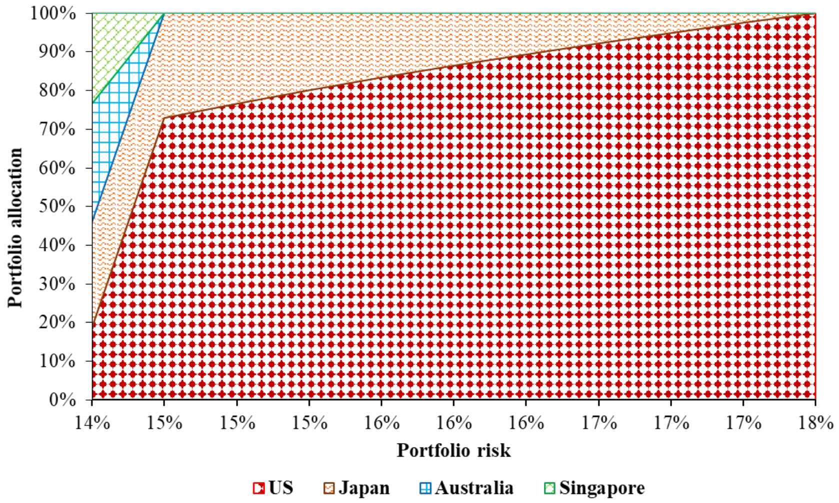
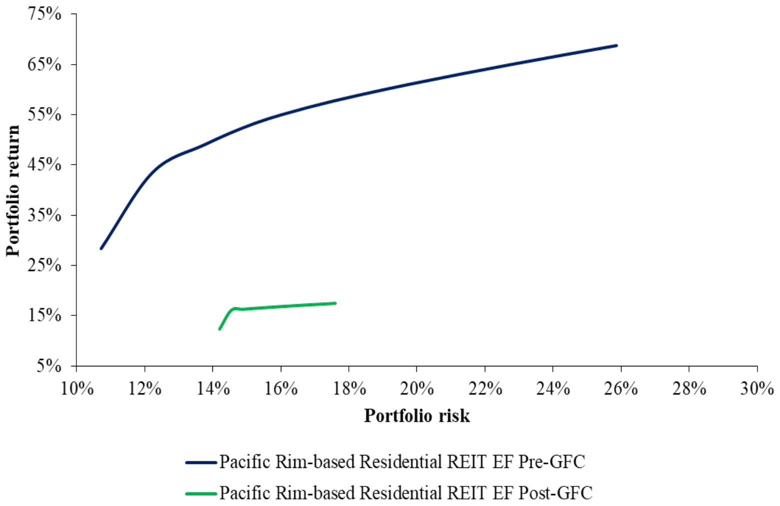


Figure 7-24: Asia-Pacific residential REIT efficient frontiers pre-GFC vs post-GFC



7.6 PERFORMANCE OF ASIA-PACIFIC SPECIALTY REIT-BASED PORTFOLIO

7.6.1 Risk-adjusted Performance Analysis

Table 7-21 reveals the risk-adjusted performance of cross-country specialty REITs across the USA, Japan, Australia and Singapore for July 2006–December 2018. Singapore offered the highest average annual returns at 14.69% p.a., exceeding the USA (7.80% p.a.), Australia (5.13% p.a.) and Japan (4.17% p.a.). Japan also had a higher risk level (29.88%) than the USA, Australia and Singapore, which recorded annual risk of 20.65%, 24.63% and 26.82%, respectively. With the highest average annual returns and comparatively lower annual risk, Singapore (return/risk ratio = 0.55) easily outpaced the other three specialty REITs on a risk-adjusted performance basis, namely the USA (0.38), Australia (0.21) and Japan (0.14). Japan, with the poorest average annual returns and highest risk level in the region, fell to the last place in risk-adjusted performance over the full study timeframe.

Table 7-21: Asia-Pacific specialty REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
US	7.80	20.65	0.38	2
Japan	4.17	29.88	0.14	4
Australia	5.13	24.63	0.21	3
Singapore	14.69	26.82	0.55	1

Note: *US dollars

7.6.2 Diversification Benefit Analysis

Table 7-22 tabulates the inter-asset correlation matrix between cross-country specialty REITs across the USA, Japan, Australia and Singapore from July 2006 to December 2018. Institutional investors seeking to construct an Asia-Pacific specialty REIT-based portfolio could obtain effective portfolio diversification benefits (average $r = 0.53$) over the entire study timeframe. The most significant observation is the low correlations between Japan and the other three specialty REITs in the region, ranging from $r = 0.48$ to $r = 0.44$. Comparatively small portfolio diversification benefits could be achieved between the USA and Singapore ($r = 0.49$) if both of these two assets were included in the regional specialty REIT-based portfolio. In contrast, Australia was strongly correlated with the USA ($r = 0.67$) and Singapore ($r = 0.65$).

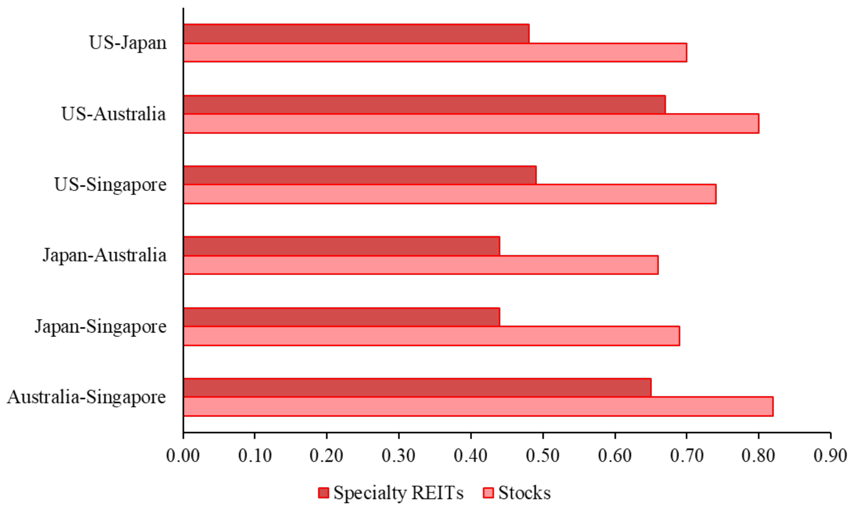
Table 7-22: Asia-Pacific specialty REIT correlation analysis*: July 2006–December 2018

	US	Japan	Australia	Singapore
US	1.00			
Japan	0.48*	1.00		
Australia	0.67*	0.44*	1.00	
Singapore	0.49*	0.44*	0.65*	1.00

Note: *Significant correlation (p<5%)

Figure 7-25 compares geographic diversification benefits between inter-specialty REIT and inter-stock investment perspectives over the entire study period. International investors seeking portfolio diversifications in the region can obtain 21% more effective geographic diversification benefits by using a cross-country inter-specialty REIT (average $r = 0.53$) investment strategy compared with a cross-country inter-stock investment strategy (average $r = 0.74$). Within a cross-country inter-specialty REIT investment framework, a Japan-Australia diversification approach ($r = 0.44$) offered stronger geographic diversification benefits than the others, such as the approaches of Japan-Singapore ($r = 0.44$), US-Japan ($r = 0.48$), US-Singapore ($r = 0.49$), Australia-Singapore ($r = 0.65$) and US-Australia ($r = 0.67$).

Figure 7-25: Country correlation: specialty REITs vs stocks: July 2006–December 2018



7.6.3 Portfolio Analysis

Table 7-23 and **Figure 7-26** show the optimal portfolio of specialty REITs in the USA, Japan, Australia and Singapore, and the expected portfolio returns and risk from July 2006 to December 2018. At the lowest end, the portfolio primarily comprised the USA (62.5%)

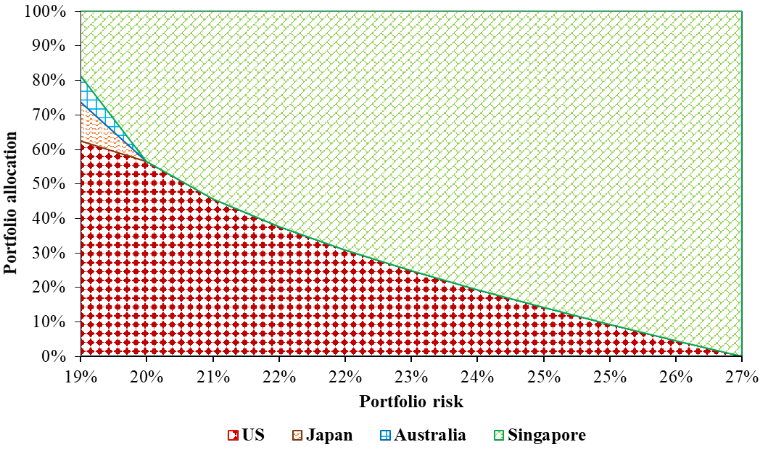
and Singapore (18.7%), with negligible portfolio share for Japan (11.3%) and Australia (7.5%). At this level, portfolio returns were 8.47% p.a., with annual risk of 19.41%. At the mid-point of the risk-return, range providing the portfolio returns and risk of 12.97% p.a. and 23.11%, respectively, the portfolio allocations consisted of Singapore (75.1%) and the USA (24.9%). At the highest risk-return level, Singapore reached a maximum portfolio allocation level at 100% and contributed portfolio returns and risk of 14.69% p.a. and 26.82%, respectively.

Singapore (average allocation = 70.5%) dominated the broad risk-return band, followed by the USA (27.8%), Japan (1.0%) and Australia (0.7%). The USA largely featured in the lower end of the risk-return range while Japan and Australia only played minor roles at the start of the risk-return scale.

Table 7-23: Asia-Pacific specialty REIT asset allocation: July 2006–December 2018

US	Japan	Australia	Singapore	Portfolio return	Portfolio risk
62.5%	11.3%	7.5%	18.7%	8.47%	19.41%
56.5%	0.0%	0.0%	43.5%	10.79%	20.15%
45.7%	0.0%	0.0%	54.3%	11.54%	20.89%
37.6%	0.0%	0.0%	62.4%	12.09%	21.63%
30.9%	0.0%	0.0%	69.1%	12.56%	22.37%
24.9%	0.0%	0.0%	75.1%	12.97%	23.11%
19.3%	0.0%	0.0%	80.7%	13.36%	23.86%
14.1%	0.0%	0.0%	85.9%	13.71%	24.60%
9.2%	0.0%	0.0%	90.8%	14.05%	25.34%
4.5%	0.0%	0.0%	95.5%	14.37%	26.08%
0.0%	0.0%	0.0%	100.0%	14.69%	26.82%

Figure 7-26: Asia-Pacific specialty REIT asset allocation diagram: July 2006–December 2018



7.6.4 Sub-period Analysis

Table 7-24 presents the risk-adjusted performance of specialty REITs across the USA, Japan, Australia and Singapore over two sub-periods, the pre-GFC (Panel A) and post-GFC (Panel B). The average annual returns of Singapore and Australia were volatile dramatically over two sub-periods, while risk-return profiles of Japan and the USA were comparatively steady. In the pre-GFC context, Singapore registered the highest average annual returns at 123.76% p.a., while Japan posted the lowest annualised returns at 9.34% p.a. In terms of annualised returns, Australia (35.36% p.a.) and the USA (14.62% p.a.) were placed between Singapore and Japan, ranked second and third place, respectively. For the annual risk level, with the highest annual returns among these four specialty REITs in the region, Singapore had higher exposure to risk (annual risk = 32.98%) than the USA (16.81%), Australia (20.05%) and Japan (20.14%). Despite having the highest annual risk level, Singapore (return/risk ratio = 3.75) offered the most competitive risk-return trade-offs due to its high average annual returns. With the second-highest average annual returns and the lowest annual risk, Japan (1.76) was rated second in terms of risk-return trade-offs, with the USA (0.87) and Australia (0.46) trailing behind.

In the post-GFC context, Singapore saw its average annual returns shrink from the pre-GFC level of 123.76% p.a. to 11.93% p.a., dropping to the last place in the average annual return ranking. It was outpaced by Australia (15.77% p.a.), Japan (15.26% p.a.) and the USA (12.25% p.a.). The annual risk level for Japan (18.76%) was higher than the USA (15.18%), Australia (16.50%) and Singapore (17.47%). On a risk-return trade-offs basis measured by the return/risk ratio, Australia (0.96) was the best performer, having the highest average annual returns and the second-lowest annual risk level. In contrast, Singapore (0.68) was last due to having the worst average annual returns and second-highest annual volatility. Japan and the USA had return/risk ratios of 0.81 and 0.81, respectively.

Table 7-24: Asia-Pacific specialty REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Return/risk ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
US	14.62	16.81	0.87	3
Japan	9.34	20.14	0.46	4
Australia	35.36	20.05	1.76	2
Singapore	123.76	32.98	3.75	1
Panel B: Post-GFC: July 2009–December 2018				
US	12.25	15.18	0.81	3
Japan	15.26	18.76	0.81	2
Australia	15.77	16.50	0.96	1
Singapore	11.93	17.47	0.68	4

Note: *US dollars

To provide an in-depth understanding of the risk-adjusted analysis, risk-return profiles of the four specialty REITs were plotted in a scatter diagram to enable peer comparison benchmarked against regional and US stocks over the pre-GFC (Panel A) and post-GFC (Panel B) periods, as displayed in **Figure 7-27**. The abnormal risk-return trade-offs of Singapore and Australia before the GFC sees these two specialty REITs located in the comparatively superior upper-left quadrant of the scatter diagram. In contrast, their higher volatility attached to a possibility of low returns sees USA and Japan placed in the lower-right – the inferior quadrant of the scatter diagram associated with low-return/low-risk investment assets. The poorest performer was Japan, which had the lowest average returns of 9.34% p.a., but the second-highest level of risk, as measured by the standard deviation of 20.14%.

After the GFC, all specialty REITs in the region are positioned in the normal quadrant for investments with a high risk-return trade-off – the upper-right quadrant of the scatter diagram. Australia offered higher risk-return trade-offs compared with the other three specialty REITs, while the USA was the riskiest specialty REIT market of the four, as discussed in the previous section. The worst performer was Singapore, which had the lowest average returns of 11.93% p.a. and the second-highest level of risk measured by the standard deviation of 17.47%. In general, these four specialty REITs featured high-return/high-risk attributes. Their risk-return profiles are inconsistent with those of the traditional listed property investment channel, which featured low-return/low-risk profiles.

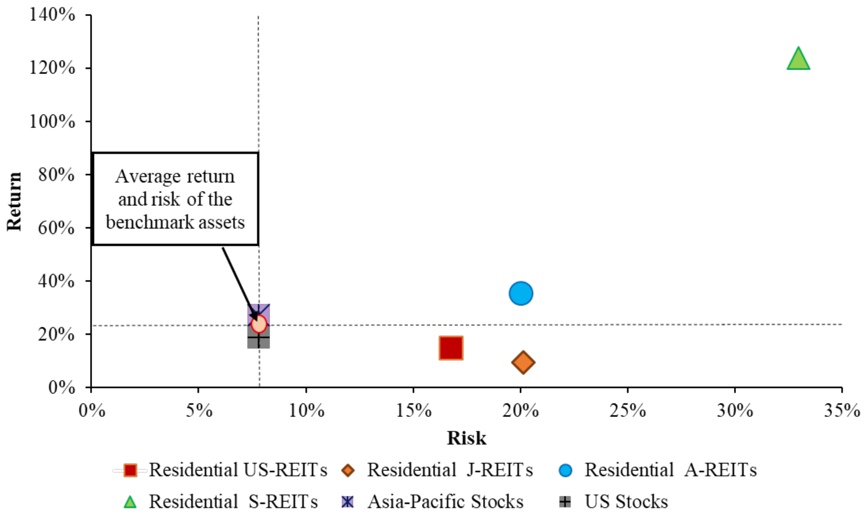
The results of the cross-country inter-Asia-Pacific specialty REITs correlation matrix over the pre-GFC (Panel A) and post-GFC (Panel B) periods are reported in **Table 7-25**. Generally, the attractive portfolio-diversifying trait of the cross-country inter-Asia-Pacific specialty REIT investment strategies over the pre-GFC (average $r = 0.25$) and the post-GFC (average $r = 0.41$) timeframes can be seen in the table, although the post-GFC portfolio diversifications level shrank from its pre-GFC level.

Prior to the GFC, the most interesting observation is that the USA was weakly correlated with Singapore (r = 0.06) and Australia (r = 0.07). However, the least portfolio diversification benefits occurred where both the USA and Japan ($r = 0.45$) were added to the portfolio. Interestingly, more appealing diversification benefits were obtained when Australia was added. For instance, the correlation coefficients of Australia with the other three specialty REITs in the region were comparatively low. These include the coefficient correlations of Australia with the USA ($r = 0.07$), Japan ($r = 0.17$) and Singapore ($r = 0.36$).

Post to the GFC, Japan offered the most attractive diversification benefits within the regional specialty REIT-based portfolio, since it was weakly correlated with the other three – the USA ($r = 0.24$), Australia ($r = 0.30$) and Singapore ($r = 0.32$). However, the correlation coefficients of Australia with Singapore and the USA were 0.65 and 0.61, respectively. This signifies that investors seeking cross-country specialty REIT-based portfolio diversifications would receive lesser diversification benefits by including Australia in their investment portfolios. The substandard portfolio diversification benefits ($r = 0.56$) were seen if both the USA and Singapore were added to the regional specialty REIT-based portfolio.

Figure 7-27: Risk and return profiles of Asia-Pacific specialty REITs

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

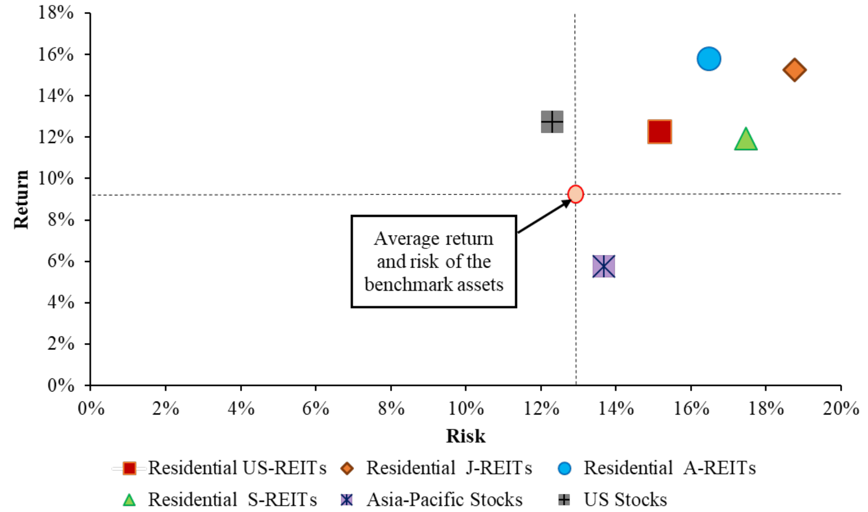


Figure 7-28 compares geographic diversification benefits between inter-specialty REIT and inter-stock investment strategies over the sub-period timeframes, including the pre-GFC (Panel A) and post-GFC periods (Panel B). A cross-country inter-specialty (average $r = 0.24$) REIT investment strategy offered 18% higher geographic diversifications than an inter-stock investment framework (average $r = 0.42$) in the pre-GFC timeframes. Similarly, a cross-country inter-specialty REIT diversification strategy (average $r = 0.45$) offered 21% greater geographic diversifications than a cross-country inter-stock diversification strategy (average $r = 0.66$) post to the GFC. Prior to the GFC, a US-Japan diversification approach ($r = 0.45$) within a cross-country inter-specialty REIT diversification strategy was 58% lesser than an inter-stock diversification strategy with

the same channel ($r = -0.13$). For the other diversification approaches in the region, a cross-country inter-specialty REIT diversification strategy was more effective than an inter-stock diversification framework in terms of geographic diversifications within the two sub-periods.

Table 7-25: Asia-Pacific specialty REIT correlation analysis*

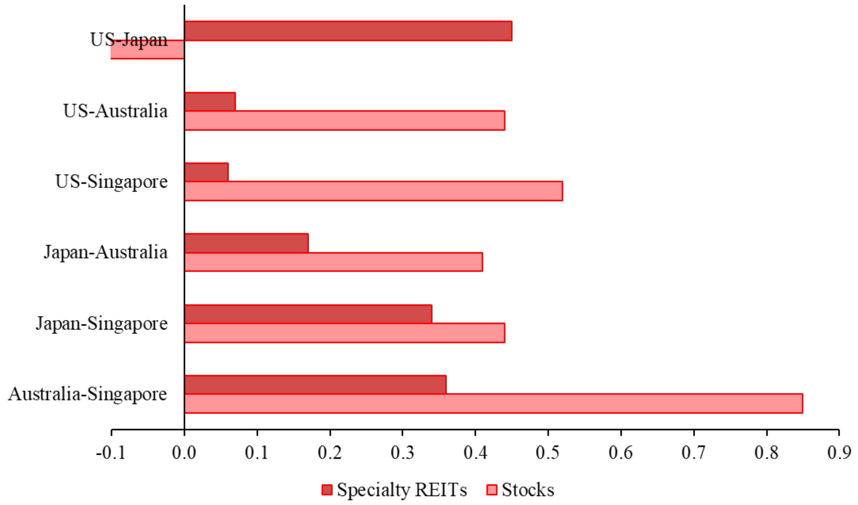
	US	Japan	Australia	Singapore
Panel A: Pre-GFC: July 2006–September 2007				
	US	Japan	Australia	Singapore
US	1.00			
Japan	0.45*	1.00		
Australia	0.07	0.17*	1.00	
Singapore	0.06	0.34*	0.36*	1.00
Panel B: Post-GFC: July 2009–December 2018				
	US	Japan	Australia	Singapore
US	1.00			
Japan	0.24*	1.00		
Australia	0.61*	0.30*	1.00	
Singapore	0.56*	0.32*	0.65*	1.00

Note: *Significant correlation (p<5%)

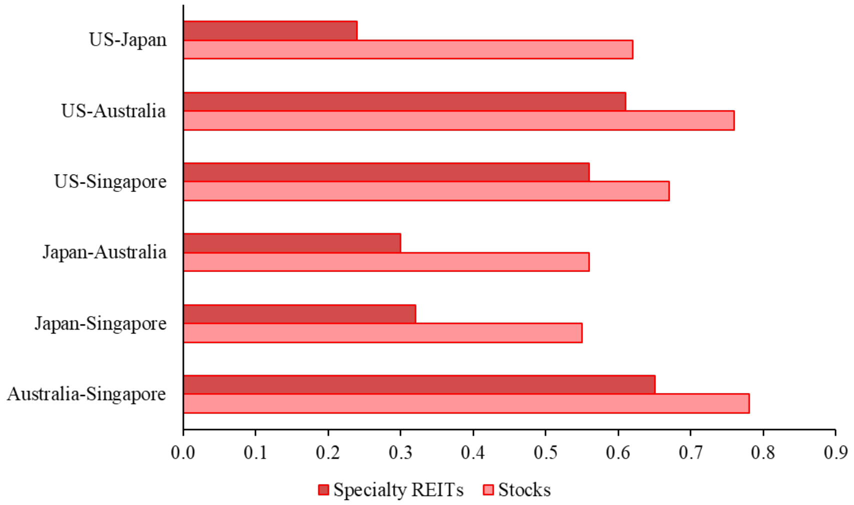
Figure 7-29 documents the compositions of the optimal cross-country specialty REIT-based portfolio based on two sub-periods, pre-GFC (Panel A) and post-GFC (Panel B). The cross-country specialty REIT-based portfolio consists of the four specialty REIT markets in the USA, Japan, Australia and Singapore. In the pre-GFC context, at the lowest end of the risk-return scale, the portfolio compositions were mainly comprised Australia (54.2%) and the USA (26.2%), since these two specialty REITs offered comparatively low annual risk levels and acceptable average annual returns. There were minor roles for Japan (16.6%) and Singapore (3.1%). At this level, portfolio returns were 28.40% p.a., corresponding to an annual risk of 13.92%. At the highest end of the risk-return range, Singapore controlled all portfolio allocations and reached a maximum level at 100%, owing to its extremely strong average annualised returns of 123.76% p.a., offering portfolio returns and risk of 123.76% p.a. and 32.98%, respectively. Singapore (average allocation = 62.8%) played a prominent role across the broad risk-return band, particularly in the higher end. It gradually weakened against the USA (20.3%), Australia (15.4%) and Japan (1.5%) when the risk level heightened.

Figure 7-28: Sub-period country correlation: specialty REITs vs stocks

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

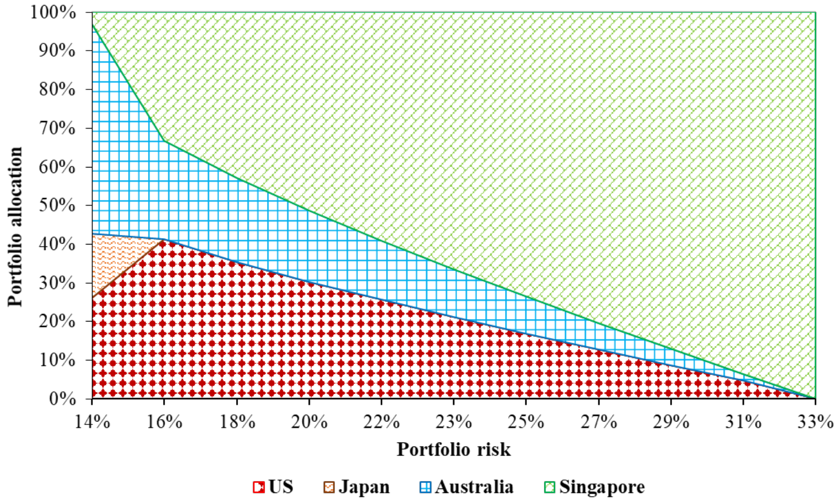


In the post-GFC context, the portfolio returns ranged from 14.08% p.a. to 15.77% p.a., with annual portfolio risk levels ranging from 13.03% to 16.50%. At the lowest end, the portfolio compositions were equally divided among the four specialty REITs in the region, at 30.6% (Australia), 27.3% (Japan), 23.3% (Singapore) and 18.8% (the USA). This is due to the comparable risk-return trade-offs for these four REITs. At the highest end, Australia played a primary role and accounted for a maximum level at 100%, since it offered the highest annual returns and second-lowest annual volatility. Overall, Australia (74.0%) played a major role across the whole risk-return band, overshadowing Japan (20.1%), the USA (3.8%) and Singapore (2.1%) when the risk level heightened.

Figure 7-30 displays the comparison of Asia-Pacific specialty REIT efficient frontiers between the pre-GFC and post-GFC periods. As presented in the figure, the pre-GFC regional specialty REIT efficient frontier was higher and wider than the post-GFC curve at each point of its risk-return range. The pre-GFC efficient frontier spanned a broader range of portfolio returns, from 28.40% p.a. to 123.76% p.a., with the risk level ranging from 13.92% to 32.98%. The post-GFC efficient frontier figured a constrained range of portfolio returns, from 14.08% p.a. to 15.77% p.a., with the risk level ranging from 13.03% to 16.50%. This indicates that the pre-GFC curve brought more portfolio enhancements but exposed investors to higher risk compared with the post-GFC curve.

Figure 7-29: Asia-Pacific specialty REIT sub-period asset allocation diagram

Panel A: Pre-GFC: July 2006–September 2007



Panel B: Post-GFC: July 2009–December 2018

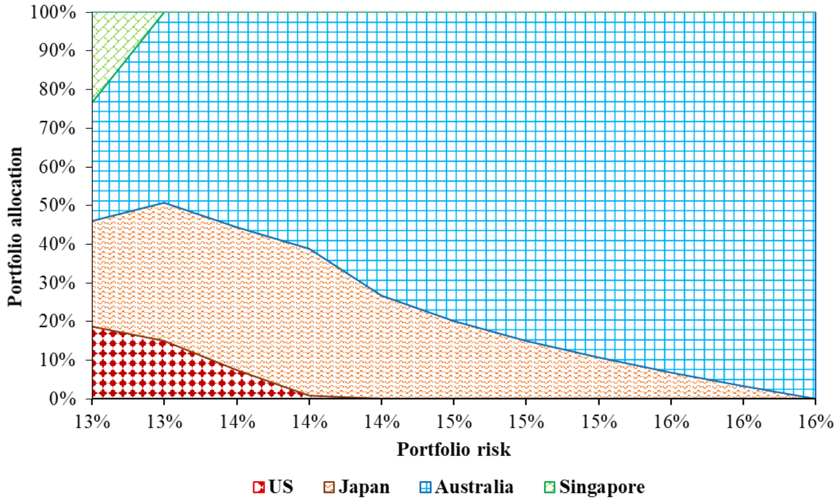
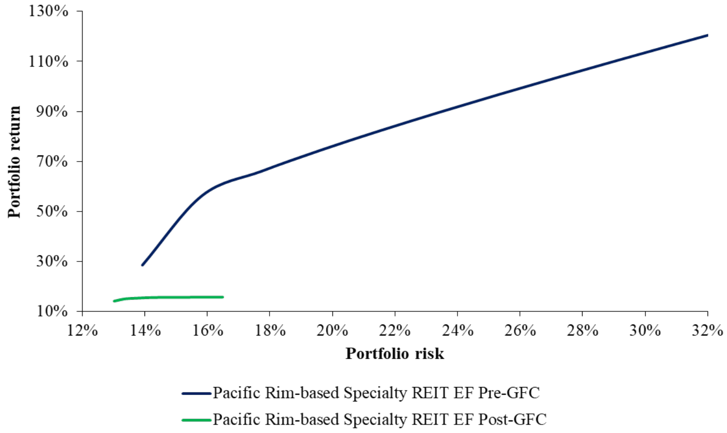


Figure 7-30: Asa-Pacific specialty REIT efficient frontiers pre-GFC vs post-GFC



In sum, the empirical results validated Asia-Pacific specialty REITs as a high-return/high-risk investment asset over the full study period. A strong portfolio-diversifying trait of the cross-country specialty REIT-based portfolio was evident, particularly before the GFC. Australia was consistently the most valuable portfolio enhancer in the pre-GFC and post-GFC investment contexts, while Singapore posted extremely high annual returns prior to the GFC.

7.7 SUMMARY OF FINDINGS

This chapter has investigated the performance of five different property types of regional REIT-based portfolios in the Asia-Pacific investment context from July 2006 to December 2018. In the cross-country investment framework, the risk-adjusted performance and portfolio analyses were measured by monthly total return indices of sector-specific REITs in Japan, Australia and Singapore based on US dollars, benchmarked against that in the USA. The following sections summarise the primary findings of this chapter.

7.7.1 Risk-adjusted Performance of Cross-country Sector-specific REITs

Table 7-26 summarises the performance of different property types of REITs in Japan, Australia and Singapore benchmarked against the USA from July 2006 to December 2018. As seen in Panel A, these three Asia-Pacific REIT markets had stronger risk-adjusted returns on the office, retail and industrial REIT markets than the USA over the full study period, while the USA generally offered stronger risk-adjusted returns on residential and specialty REIT markets. Nonetheless, superior risk-adjusted returns of specialty REITs was seen in Singapore compared with the USA over the entire study period.

Time-varying results have been reported in the sub-period analysis, as reported in Panel B. Prior to the GFC, higher risk-adjusted returns for office, retail, industrial, residential and specialty REIT markets were witnessed in the Asia-Pacific REIT markets compared with the USA. However, the USA had higher risk-adjusted returns on retail, industrial and specialty REIT markets than Japan. Post to the GFC, the resurgence in the USA can be seen in the retail, industrial and residential REIT markets, as these three sector-specific REIT markets in the USA provided superior risk-adjusted performance to the Asia-Pacific REIT markets (Panel C). In addition, the USA had higher risk-adjusted returns on the office REIT market than Japan, and greater risk-adjusted returns on the specialty REIT markets than Singapore. Australia is the only REIT market in the Asia-Pacific offering the superior risk-adjusted returns on the office, industrial and specialty REIT markets to the USA, as well as to the office REIT market in Singapore and the specialty REIT market in Japan.

These findings indicate that the Asia-Pacific office, retail and industrial REIT markets outperformed the USA markets in terms of risk-adjusted returns over the study period. However, the USA offered a resurgence in the office and residential REIT markets on a risk-adjusted return basis after the GFC. This implies differential risk-adjusted returns for each property type of REIT across the four markets. This can be attributed to distinct risk-return attributes of different property markets in these four markets, highlighting the importance of a detailed analysis of each REIT market in providing a fuller understanding of sector-specific REITs.

Table 7-26: Cross-country sector-specific REIT performance summary: different property types of regional REIT-based portfolios

Did sector-specific REITs in the USA offer better performance compared with sector-specific REITs in Japan, Australia and Singapore?

	Asset	Return	Risk	Risk-adjusted return
Panel A: Whole period				
Office portfolio	1	✗	✗	✗
	2	✗	✗	✗
	3	✗	✓	✗
Retail portfolio	1	✗	✗	✗
	2	✗	✗	✗
	3	✗	✗	✗
Industrial portfolio	1	✗	✗	✗
	2	✗	✗	✗
	3	✗	✗	✗
Residential portfolio	1	✓	✗	✓
	2	✓	✓	✓
	3	✓	✓	✓
Specialty portfolio	1	✓	✓	✓
	2	✓	✓	✓
	3	✗	✓	✗
Panel B: Pre-GFC				
Office portfolio	1	✗	✓	✗
	2	✗	✗	✗
	3	✗	✓	✗
Retail portfolio	1	✓	✗	✓
	2	✗	✗	✗
	3	✗	✗	✗
Industrial portfolio	1	✓	✓	✓
	2	✗	✗	✗
	3	✗	✓	✗
Residential portfolio	1	✗	✗	✗
	2	✗	✗	✗
	3	✗	✓	✗
Specialty portfolio	1	✓	✓	✓
	2	✗	✓	✗
	3	✗	✓	✗

Note: 1 = Japan, 2 = Australia, 3 = Singapore

Table 7-27: Cross-country sector-specific REIT performance summary: different property types of regional REIT-based portfolios (Cont1)

Did sector-specific REITs in the USA offer better performance compared with sector-specific REITs in Japan, Australia and Singapore?				
	Asset	Return	Risk	Risk-adjusted return
Panel C: Post-GFC				
Office portfolio	1	✔	✔	✔
	2	✕	✕	✕
	3	✕	✔	✕
Retail portfolio	1	✔	✔	✔
	2	✔	✕	✔
	3	✔	✕	✔
Industrial portfolio	1	✔	✕	✔
	2	✔	✕	✕
	3	✔	✕	✔
Residential portfolio	1	✔	✕	✔
	2	✔	✔	✔
	3	✔	✕	✔
Specialty portfolio	1	✕	✔	✕
	2	✕	✔	✕
	3	✔	✔	✔

Note: 1 = Japan, 2 = Australia, 3 = Singapore

7.7.2 Portfolio Diversification Benefits of Cross-country Sector-specific REITs

Table 7-28 and **Figure 7-25** compare the geographic diversification benefits from sectoral REIT and inter-stocks perspectives, and the sectoral REIT diversification benefits from a country perspective in the Asia-Pacific region and the US investment contexts over the full study period. As documented in Panel A, the overall picture from this analysis suggests that stronger geographic diversification benefits can be achieved for investors seeking a cross-country sectoral REITs (average $r = 0.51$) investment strategy in the region compared with an inter-stocks (average $r = 0.74$) investment framework. Within a sectoral REIT investment framework, the inter-industrial REIT investment strategy (average $r = 0.44$) offered the best geographic diversification for investors seeking portfolio diversifications in the Asia-Pacific region and the US investment contexts over the full study period. It was followed by the inter-office (average $r = 0.52$), specialty (average $r = 0.53$), retail (average $r = 0.53$) and residential REIT investment strategies (average $r = 0.55$). However, investors using a US-Australia or US-Singapore diversification approach could attain the strongest geographic diversification benefits by investing in the inter-residential REIT investment strategy. Similarly, the strongest geographic diversification under the inter-specialty REIT investment strategy was provided by the Australia-Singapore diversification approach. Apart from a geographic diversification strategy, more appealing sectoral REIT diversification benefits could be achieved by using a US-Japan diversification approach (average $r = 0.34$) compared with the other approaches, such as Japan-Australia (average $r = 0.45$), Japan-Singapore (average $r = 0.48$), US-Singapore (average $r = 0.50$), US-Australia (average $r = 0.60$) and Australia-Singapore (average $r = 0.70$).

Time-varying results of both geographic and sectoral diversifications of sectoral REIT investment strategies are shown in **Table 7-28** and **Figure 7-31**. The full period results were buttressed by the post-GFC outcomes, in which investors seeking portfolio diversifications in the region could achieve stronger geographic diversifications by employing a sectoral REIT (average $r = 0.47$) investment strategy compared with an inter-stocks (average $r = 0.66$) investment framework. An inter-office REIT ($r = 0.79$) investment strategy offered 1% less geographic diversifications than an inter-stock ($r = 0.78$) investment framework via an Australia-Singapore diversification approach in the post-GFC context. Within a sectoral REIT investment framework, the inter-residential REIT investment strategy offered the best geographic diversification benefits (average $r = 0.42$) for investors seeking portfolio diversifications in the region in the post-GFC context, followed by inter-specialty (average $r = 0.45$), office (average $r = 0.48$), industrial (average $r = 0.50$) and retail REIT investment strategies (average $r = 0.52$). In terms of a sectoral REIT diversification strategy, the post-GFC findings were consistent with the full period results.

Prior to the GFC, an inter-stock (average $r = 0.42$) investment strategy could offer attractive geographic diversifications for investors seeking portfolio diversification benefits in the Asia-Pacific region and the US contexts. However, it was 8% lesser than a sectoral REITs (average $r = 0.34$) investment strategy. Investors could obtain the strongest geographic diversification benefits by using a sectoral REIT investment framework via a US-Singapore diversification approach (average $r = 0.10$). Within a sectoral REIT investment strategy, the inter-residential REIT investment strategy (average $r = 0.20$) offered the strongest geographic diversification for investors building regional REIT-based portfolios. It was followed by inter-specialty (average $r = 0.24$), industrial (average $r = 0.30$), office (average $r = 0.44$) and retail REIT investment strategies (average 0.51). In terms of a sectoral REIT diversification strategy, investors could receive the most attractive sectoral diversification benefits by adopting a US-Singapore diversification approach (average $r = 0.10$), followed by the approaches of US-Australia (average $r = 0.27$), Japan-Australia (average $r = 0.32$), Japan-Singapore (average $r = 0.41$), US-Japan (average $r = 0.43$) and Australia-Singapore (average $r = 0.48$).

In brief, these findings highlight the superior geographic diversification benefits of a sectoral REIT investment strategy over an inter-stock investment strategy in the region over the study period, particularly after the GFC. Strong sectoral diversification benefits of a sectoral REIT investment strategy in the region could be achieved by investing in cross-country sector-specific REITs across Japan, Australia, Singapore and the USA. These findings can inform institutional investors and provide a rationale for actively making their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than passively relying on a diversified REIT with multiple property sectors.

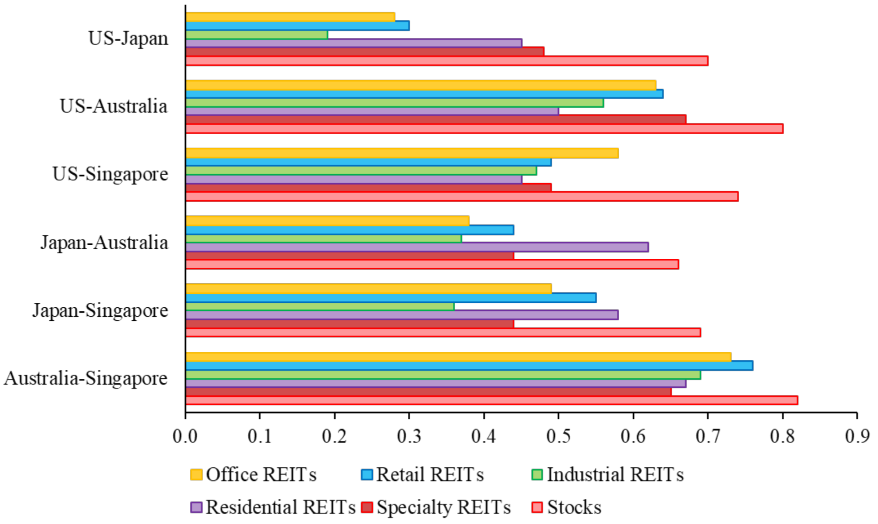
Table 7-28: Cross-country REIT sub-sector correlation matrix summary

	Office	Retail	Industrial	Residential	Specialty	Stocks
Panel A: Whole period						
1-2	0.28	0.30	0.19	0.45	0.48	0.70
1-3	0.63	0.64	0.56	0.50	0.67	0.80
1-4	0.58	0.49	0.47	0.45	0.49	0.74
2-3	0.38	0.44	0.37	0.62	0.44	0.66
2-4	0.49	0.55	0.36	0.58	0.44	0.69
3-4	0.73	0.76	0.69	0.67	0.65	0.82
Panel B: Pre-GFC						
1-2	0.62	0.73	0.13	0.23	0.45	−0.13
1-3	0.44	0.49	0.48	−0.13	0.07	0.44
1-4	0.38	0.23	−0.05	−0.10	0.06	0.52
2-3	0.22	0.59	0.26	0.36	0.17	0.41
2-4	0.48	0.51	0.29	0.44	0.34	0.44
3-4	0.50	0.48	0.66	0.40	0.36	0.85
Panel C: Post-GFC						
1-2	0.19	0.25	0.30	0.24	0.24	0.62
1-3	0.68	0.67	0.66	0.49	0.61	0.76
1-4	0.56	0.54	0.43	0.36	0.56	0.67
2-3	0.28	0.43	0.43	0.40	0.30	0.56
2-4	0.35	0.45	0.48	0.40	0.32	0.55
3-4	0.79	0.77	0.68	0.63	0.65	0.78

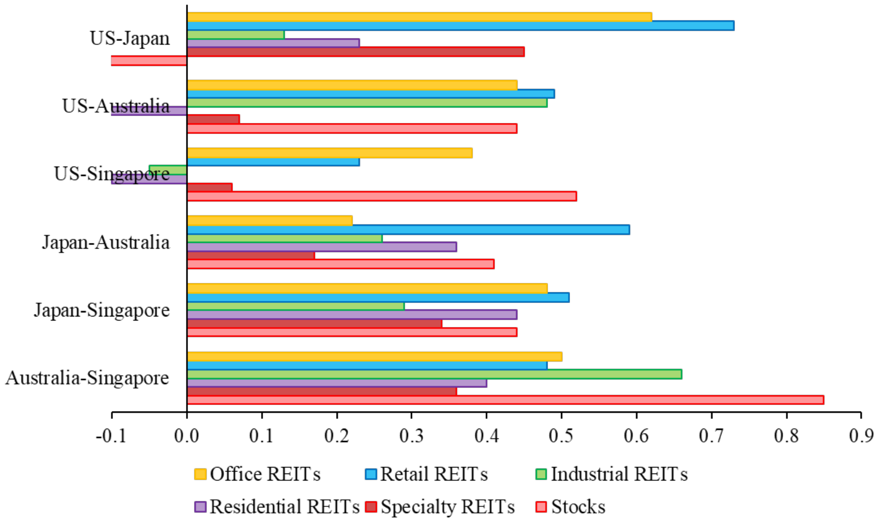
Note: 1 = US, 2 = Japan, 3 = Australia, 4 = Singapore

Figure 7-31: Cross-country correlation summary: sector-specific REITs vs stocks

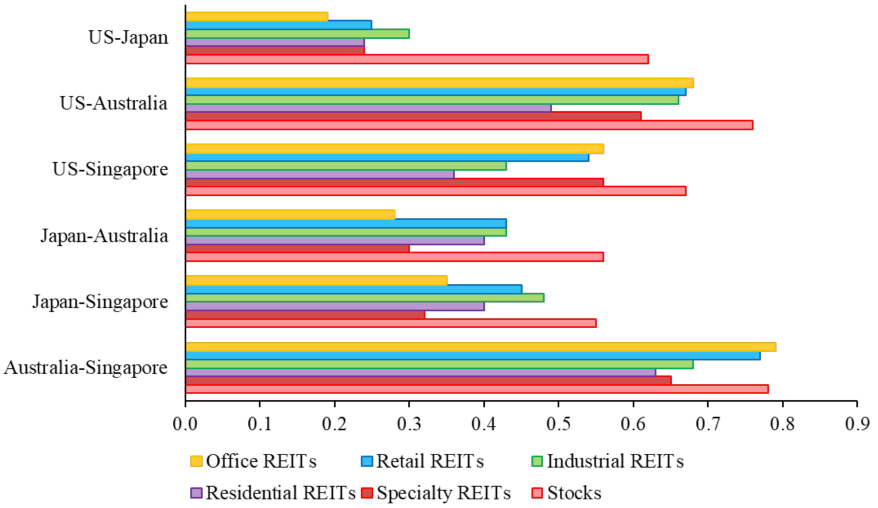
Panel A: Whole period



Panel B: Pre-GFC



Panel C: Post-GFC



7.7.3 Roles of Cross-country Sector-specific REITs in Different Property Types of Regional REIT-based Portfolios

Table 7-29 tabulates the optimal portfolio allocations of sector-specific REITs in Japan, Australia and Singapore in the corresponding regional REIT-based portfolio, benchmarked against that in the USA from July 2006 to December 2018, including the two sub-period timeframes. These findings show that Singapore dominated the optimal portfolio compositions of the regional office (58.7%), retail (58.8%), industrial (90.1%) and specialty (70.5%) REIT-based portfolios over the entire study period. On the other hand, the USA played a prominent role (72.2%) in the regional residential REIT-based portfolio, followed by Singapore (18.6%) and Japan (9.2%).

Time-varying portfolio compositions of sector-specific REITs in these four markets within the corresponding regional REIT-based portfolio are portrayed in **Table 7-29**. The pre-GFC results are generally consistent with the full period findings, in which Singapore played a prominent role in the regional office, retail and industrial REIT-based portfolios. Singapore (55.8%) and Australia (54.2%) played major roles in the regional residential and specialty REIT-based portfolios, respectively. Post to the GFC, the renaissance in the US-REIT market contributed to making it the pre-eminent player in the regional retail (67.7%), industrial (68.7%) and residential (81.1%) REIT-based portfolios. However, the USA failed to be a major contributor to the regional office and specialty REIT-based portfolios. In the regional office REIT-based portfolio, the USA (6.4%) was surpassed by Australia (75.7%) and Japan (16.8%) but exceeded Singapore (1.0%). In the regional specialty REIT-based portfolio, the optimal portfolio allocations were divided among the four REIT markets, Australia (30.6%), Japan (27.3%), Singapore (23.3%) and the USA (18.8%).

Briefly, these findings indicate the varying portfolio allocations of sector-specific REITs among different types of property sectors and across these four markets. These variations can be attributed to their distinct risk-adjusted performance and correlations with one another in each of the four markets. These have been particularly important for institutional investors with a mandate to build regional REIT-based portfolios, since sector-specific REITs behaved differently in terms of risk-return attributes across property sectors and different markets.

Table 7-29: Cross-country sector-specific REITs in different property types of regional REIT-based portfolios asset allocation summary

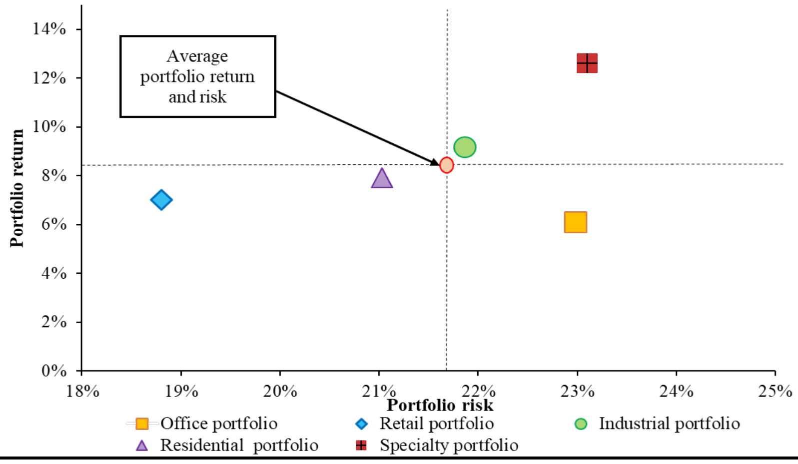
Regional portfolios	Japan	Australia	Singapore	US
Panel A: Whole period				
Office	34.6%	3.8%	58.7%	2.9%
Retail	20.3%	20.9%	58.8%	0.0%
Industrial	3.4%	6.5%	90.1%	0.0%
Residential	9.2%	0.0%	18.6%	72.2%
Specialty	1.0%	0.7%	70.5%	27.8%
Panel B: Pre-GFC				
Office	2.6%	32.6%	64.1%	0.8%
Retail	0.0%	35.5%	63.9%	0.6%
Industrial	3.0%	41.7%	54.4%	3.0%
Residential	1.5%	38.5%	55.8%	4.1%
Specialty	16.6%	54.2%	3.1%	26.2%
Panel C: Post-GFC				
Office	16.8%	75.7%	1.0%	6.4%
Retail	6.3%	2.8%	23.2%	67.7%
Industrial	17.1%	8.9%	5.3%	68.7%
Residential	14.0%	2.8%	2.1%	81.1%
Specialty	27.3%	30.6%	23.3%	18.8%

7.7.4 Portfolio Returns and Risk of Different Property Types of Regional REIT-based Portfolios

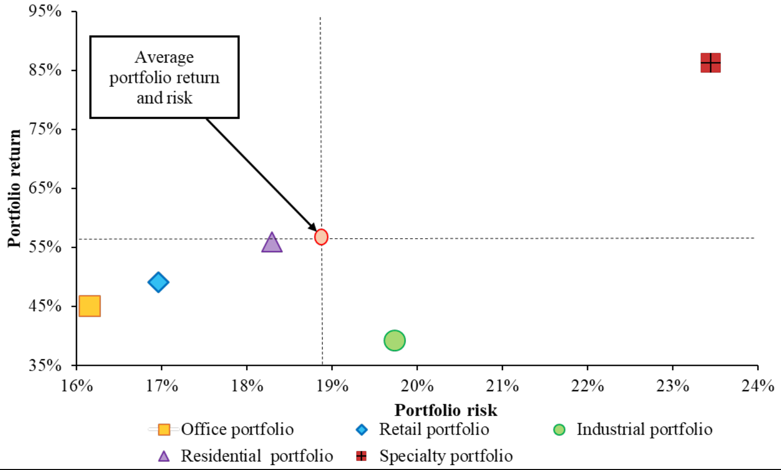
Figure 7-32 and **Figure 7-33** depict portfolio returns and risk of five different property types of regional REIT-based portfolios in the Asia-Pacific from July 2006 to December 2018. The full period results show that the regional industrial REIT-based portfolio offered higher portfolio returns at each point of the portfolio risk-return spectrum than the other property types of regional REIT-based portfolios, evident by its shorter and steeper efficient frontier. Higher portfolio returns with a higher portfolio risk level could be achieved by the regional specialty portfolio. In contrast, the regional retail and residential REIT-based portfolios offered portfolio returns with a lower risk level, while the regional office REIT-based portfolio delivered a higher risk level but failed to enhance portfolio returns. Prior to the GFC, despite the fact that the regional specialty REIT-based portfolio exhibited a steeper upward shift of the curve than the other regional REIT-based portfolios, it exposed investors to a higher level of portfolio risk, evident by its wider efficient frontier curve. On the other hand, the regional office, retail and residential REIT-based portfolios provided portfolio returns with a lower level of portfolio volatility. Nonetheless, the regional industrial REIT-based portfolio was unsuccessful in enhancing portfolio returns but exposed investors to a higher portfolio risk level. Post to the GFC, the regional specialty REIT-based portfolio delivered the highest level of portfolio returns. Compared with the regional specialty REIT-based portfolio, the regional industrial and residential REIT-based portfolios offered a higher level of portfolio returns with a higher level of portfolio volatility. Conversely, the regional office and retail REIT-based portfolios failed to provide higher portfolio returns but exposed investors to higher risk levels. In short, international property investors with a mandate to build a regional REIT-based portfolio are advised to invest in regional industrial, residential and specialty REIT-based portfolios with higher portfolio returns and risk levels. On the other hand, conservative property investors are advised to build regional office and retail REIT-based portfolios, since they expose investors to a lower level of risk. These findings are particularly important to institutional investors seeking listed property exposure in the Asia-Pacific, validating the distinct risk-return profiles of Asia-Pacific sector-specific REITs.

Figure 7-32: Different property types of regional REIT-based portfolio risk and return profiles summary

Panel A: Whole period



Panel B: Pre-GFC



Panel C: Post-GFC

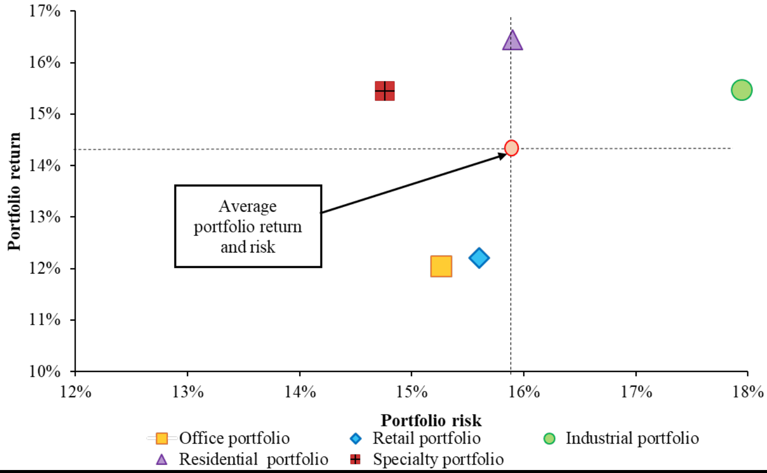
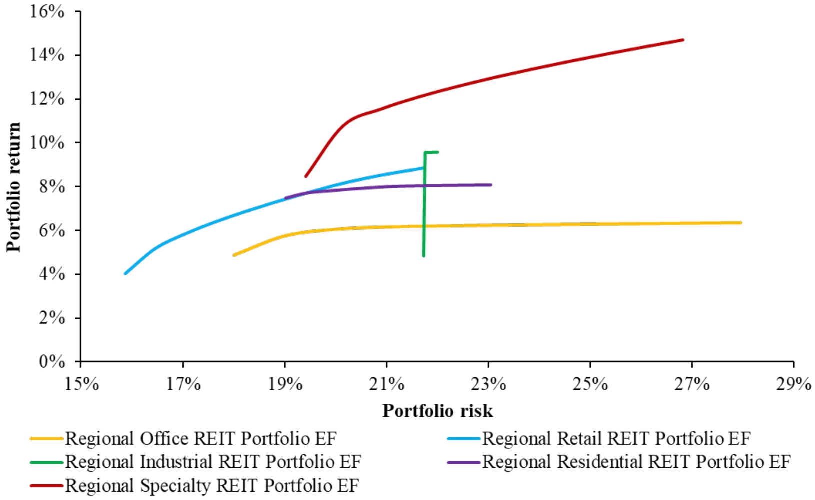
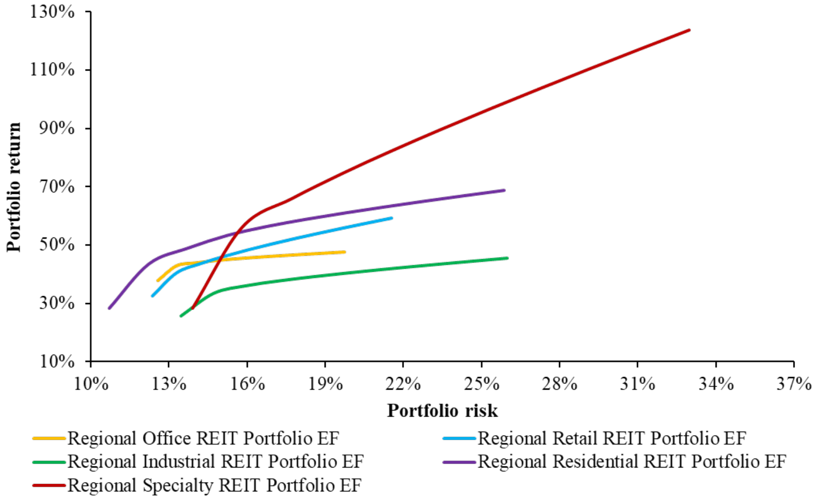


Figure 7-33: Different property types of regional REIT-based portfolio efficient frontiers summary

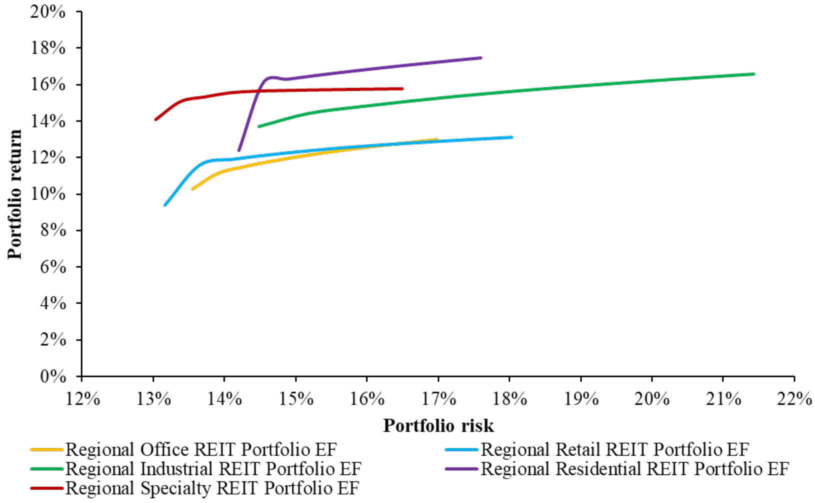
Panel A: Whole period



Panel B: Pre-GFC



Panel C: Post-GFC



7.8 SUMMARY OF CHAPTER

Overall, this chapter has demonstrated the practical implications of constructing five different property types of regional REIT-based portfolios in the Asia-Pacific from July 2006 to December 2018. These research outcomes are particularly informative for institutional investors building regional REIT-based portfolios. These findings confirm the distinct risk-return attributes of sector-specific REITs among different types of property sectors and across various jurisdictions in Japan, Australia, Singapore and the USA. The results also demonstrate the variation in portfolio returns, risk and asset allocation strategies across five different property types of regional REIT-based portfolios. The strong geographic and sectoral diversification benefits of a sectoral REIT investment strategy are also confirmed, reinforcing the view that institutional investors should actively make their own sectoral portfolio diversification decisions by investing in different property types of regional REIT-based portfolios, rather than passively relying on a diversified REIT portfolio.

In this chapter, the analyses have focused on the investment performance, portfolio diversification benefits and asset allocations of five different property types of regional REIT-based portfolios in the Asia-Pacific region. To offer an in-depth understanding of the risk management, the next chapter will investigate the interest rate risk and assess the interest risk sensitivity of Asia-Pacific sector-specific REITs.

CHAPTER 8
THE INTEREST RATE SENSITIVITY OF ASIA-PACIFIC SECTOR-SPECIFIC REITs

Chapter 8 employs the GARCH-M specification to examine the interest rate sensitivity of sector-specific REITs in the Asia-Pacific from 19 July 2006 to 31 December 2018, including the pre-GFC and post-GFC timeframes. The key investment issue is whether changes in the level and volatility of short- and long-term interest rates affect excess returns of sector-specific REITs, including office, retail, industrial, residential, specialty and diversified REITs across Japan, Australia and Singapore. The results of this chapter were externally validated by the author in a Journal of Property Investment & Finance article titled "Varying interest rate sensitivity of different property sectors: cross-country evidence from REITs", in which the disparities in interest rate sensitivity of REITs across different property sectors and Pacific Rim markets were found.

8.1 INTRODUCTION

Following on from the preceding chapters assessing the performance of Asia-Pacific sector-specific REITs, this chapter aims to investigate whether Asia-Pacific sector-specific REITs are affected by interest rate risk (RQ5). The primary purpose of this study is to ascertain the interest rate sensitivity of Asia-Pacific sector-specific REIT markets across Japan, Australia and Singapore in general, and six REIT sub-sectors (office, retail, industrial, residential, specialty and diversified REITs) in particular from 19 July 2006 to 31 December 2018. The primary interest of this chapter is the magnitude and direction of the effects of both the level and volatility of short- and long-term interest rates on daily excess returns for sector-specific REITs across various domestic jurisdictions in the Asia-Pacific region.

The rationale for this study is the current historically low interest rate environment, resulting in low property market capitalisation yields that have depressed global property transaction activities since 2016 (Deloitte, 2017; JLL, 2016b; 2017; PREI, 2017b; CBRE, 2018a, c; RCA, 2018b). The historically low level of interest rate has been fuelled by a loose monetary policy (Quantitative Easing, QE), which has injected liquidity via providing money and cutting interest rates in order to stimulate borrowing and spending activities following the downturn caused by the global economic recession (Volker, 2009;

Claessens *et al*., 2010; Mishkin, 2011; Rey, 2013; Claeys and Leandro, 2016). Under the circumstances, numerous practitioners, policymakers and scholars have discussed how property markets will behave in response to the inevitable future rises in interest rates in the international context (Devaney, 2001; Liow and Huang, 2006; Bredin *et al*., 2007; Stevenson *et al*., 2007; Lee *et al*., 2014; Akimov *et al*., 2020). Since interest rates are highly related to future economic conditions and capture the potential of investment opportunities, higher interest rates potentially decrease REIT profits and returns (Swanson *et al*., 2002; Ling *et al*., 2003; Bredin *et al*., 2007, 2011; Cheong *et al*., 2009; Chang *et al*., 2011; Akimov *et al*., 2015; Lee *et al*., 2017). This implies that interest rates will affect excess returns of REITs negatively. However, very little research has been conducted on the issue in the context of the Asia-Pacific property markets (Liow *et al*., 2013; Liow and Huang, 2006; Su *et al*., 2010; Lee *et al*., 2017). Additionally, no comparable study has been devoted to the issue at a sector-specific REIT level, despite the fact that different sector-specific REITs behave differently on a risk-return basis.

Following previous studies – such as Devaney (2001), Liow and Huang (2006), Bredin *et al*. (2007); Stevenson *et al*. (2007) and Lee *et al*. (2014) – this study employs a GARCH-M specification to assess the interest rate sensitivity of Asia-Pacific sector-specific REITs, as first used by Elyasiani and Mansur (1998) in their analysis of financial institutions. Hypotheses 8 and 7 are that changes in interest rate level have no effect on excess returns of Asia-Pacific sector-specific REITs (H_8: $\theta_j = v_{2j} = 0$), and that fluctuations in interest rate volatility have no effects on Asia-Pacific sector-specific REIT excess returns (H_7: $v_{2j} = 0$). The magnitude and direction of both 3-month and 10-year interest rate effects are empirically assessed, and the estimates will be discussed in the following sections. This is despite that sector-specific borrowing rates may be more relevant in explaining the returns of different property sectors. However, this study is unable to access daily sector-specific borrowing rates across the four markets, due to the lack of daily sector-specific borrowing rates in each case. This is given that daily data was used in this study to reflect a more intuitive relationship with the capital markets across the sample markets.

This study contributes to the existing literature by providing:

- the first empirical evidence on the sensitivity of different property types of REITs to interest rate changes;
- the first empirical evidence on the interest rate sensitivity of different property types of REITs across various markets in the Asia-Pacific; and
- updated evidence on the sensitivity of different property types of REITs to interest rate changes in the post-GFC context.

Sections 8.1, 8.2 and 8.3 provide interest rate sensitivity analyses for sector-specific REITs in Japan, Australia and Singapore, respectively, while Section 8.4 discusses the findings and concludes the chapter.

8.2 INTEREST RATE SENSITIVITY OF SECTOR-SPECIFIC REITs IN JAPAN

8.2.1 GARCH-M Specification

Table 8-1 reports summary statistics for daily excess returns of six J-REIT sub-sectors, as well as the statistical testing for normality from 19 July 2006 to 31 December 2018. This shows that sector-specific REITs offered higher excess returns than their diversified counterparts. In terms of risk measured by the standard deviation, all J-REIT sub-sectors had a daily standard deviation in excess of 1%, with retail REITs the most volatile REIT sub-sector in Japan during the study period. Positive skewness is exhibited for office, retail and industrial REITs, while negative skewness is witnessed for diversified, residential and specialty REITs. In addition, all J-REIT sub-sector distributions exhibit excess kurtosis. The dynamics of 3-month and 10-year interest rates are shown in **Figure 8-1**. The plots of daily excess returns for each J-REIT sub-sector are displayed in **Figure 8-2**. The main finding is a visual representation of the volatility of all J-REIT sub-sector series during 2007–2009, indicating the GFC period brought high volatility to all J-REIT sub-sector series. Excess returns show time-varying attributes with volatility clustering effects during the sample period, suggesting the suitability of a GARCH approach to model six J-REIT sub-sector excess returns.

The suitability of a GARCH framework for six J-REIT sub-sector series is strengthened by **Figure 8-3**, graphing the ACF of both excess returns and the volatility of J-REIT sub-sector series, with the ACF displayed over 36 lags. The results show that lower persistence in excess returns is contrasted by relatively strong persistence in the volatility series. This finding is attributed to the volatility clustering of financial time series, particularly for daily REIT data. The findings are consistent with the outcomes of Cotter and Stevenson (2004) and Stevenson *et al*. (2007), in which the strong serial correlation of volatility implies the existence of the ARCH effects for daily excess REIT returns and validates the application of GARCH-related processes to daily REIT series. The persistence of volatility is in line with a similar pattern of financial time series. The volatility clustering characteristics of sector-specific J-REIT excess return series were also confirmed by the LM tests, supporting the use of GARCH-related frameworks, as shown in **Table 8-1**.

Table 8-1: Summary statistics for Japan sector-specific REITs: July 2006–December 2018

	Diversified	**Office**	**Retail**	**Industrial**	**Residential**	**Specialty**
Mean(%)	0.030	0.034	0.034	0.045	0.033	0.028
Median(%)	0.023	0.015	0.016	0.013	0.019	0.016
Maximum(%)	10.093	12.122	12.441	16.620	8.925	12.250
Minimum(%)	−12.195	−11.774	−11.249	−13.176	−11.479	−14.316
Standard deviation(%)	1.404	1.555	1.727	1.643	1.303	1.701
Skewness	−0.082	0.073	0.238	0.160	−0.368	−0.448
Kurtosis	12.817	12.833	11.163	14.584	13.964	16.832
Jarque-Bera	13,050.29***	13,092.19***	9,050.25***	18,179.72***	16,347.18***	26,009.32***
LM test	377.951***	356.603***	329.294***	89.702***	207.862***	266.580***

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

Figure 8-1: 3-month and 10-year interest rates in Japan: July 2006–December 2018

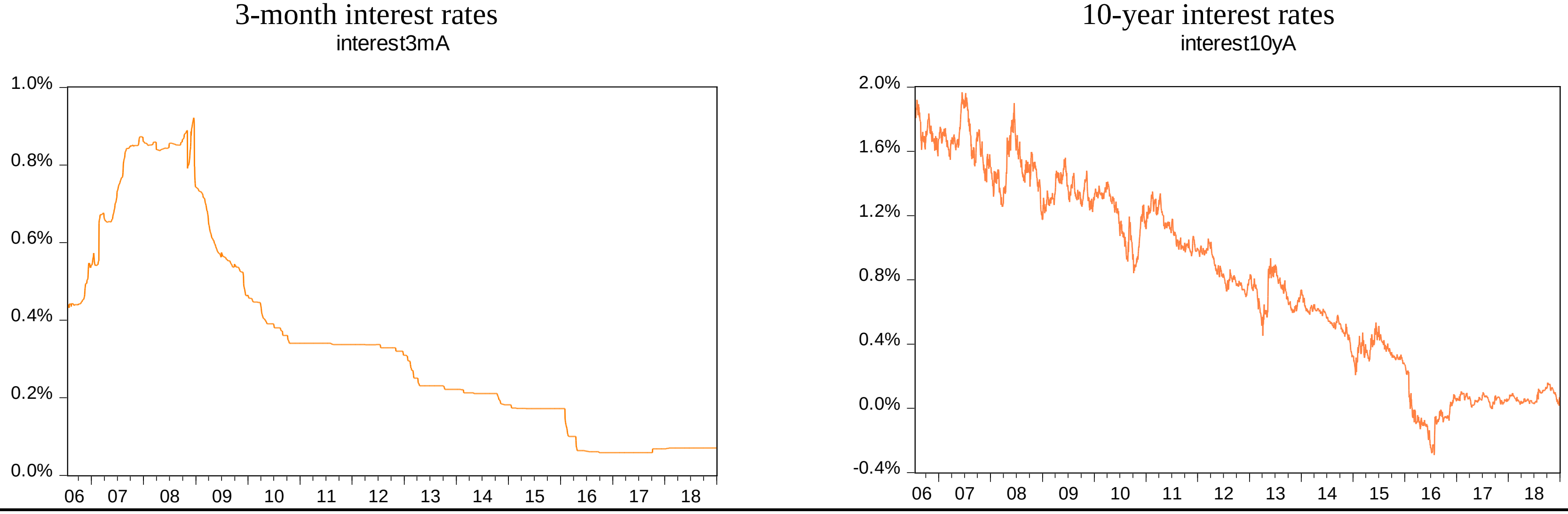


Figure 8-2: Excess returns for Japan sector-specific REITs: July 2006–December 2018

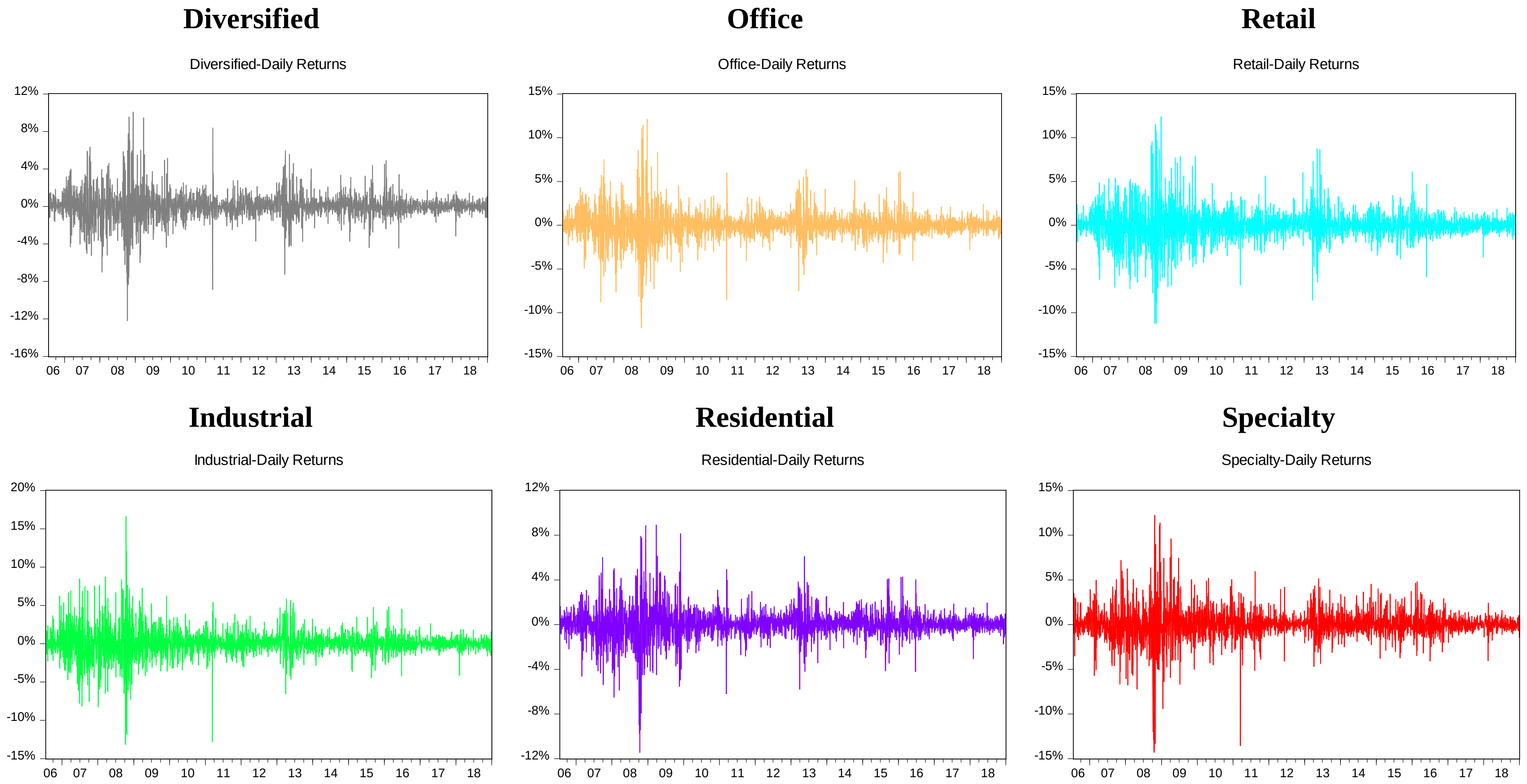


Figure 8-3: Autocorrelation plots for excess returns and volatility of Japan sector-specific REITs: July 2006–December 2018

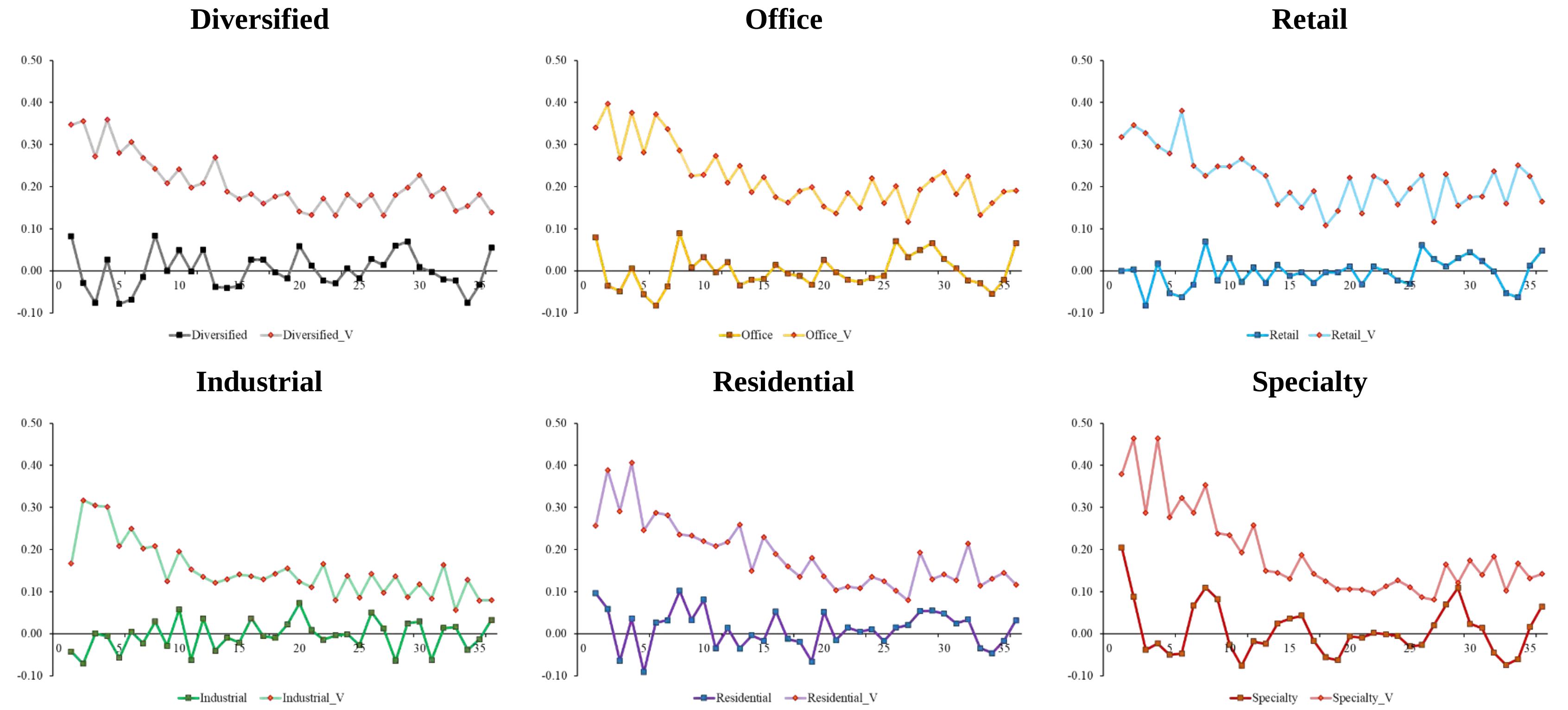


Table 8-2: ADF unit test for Japan sector-specific REITs: July 2006–December 2018

Variable	Level		First differences		Stationary
	t-statistics	p-value	t-statistics	p-value	
Diversified	−26.632	0.000	−20.808	0.000	$I(0)$
Office	−20.872	0.000	−21.630	0.000	$I(0)$
Retail	−26.663	0.000	−20.866	0.000	$I(0)$
Industrial	−44.249	0.000	−24.793	0.000	$I(0)$
Residential	−18.009	0.000	−20.230	0.000	$I(0)$
Specialty	−17.054	0.000	−20.879	0.000	$I(0)$
Market	−57.047	0.000	−23.132	0.000	$I(0)$
IR 3m	−1.092	0.250	−22.580	0.000	$I(1)$
IR 10y	−4.076	0.007	−60.593	0.000	$I(0)$
Market Vol.	−7.525	0.000	−22.155	0.000	$I(0)$
IR 3m Vol.	−56.221	0.000	−26.409	0.000	$I(0)$
IR 10y Vol.	−5.887	0.000	−57.955	0.000	$I(0)$

Note: H_0-non-stationary

Table 8-2 describes the Augmented Dickey-Fuller (ADF) test on the level of and first differences for daily excess returns of six J-REIT sub-sector series and the market equity index, as well as 3-month (IR 3m) and 10-year interest rate series (IR 10y) from 19 July 2006 to 31 December 2018, with the respective volatilities of the market equity index, 3-month and 10-year interest rates. The results indicate that all variables were stationary at a 1% significant level without unit roots. The only exception is 3-month interest rates, which refutes the null hypothesis of unit root only after being restated in first differences. This has seen the first difference in 3-month interest rate series and shown that the six J-REIT sub-sector series are constant over time. The data series are appropriate for further analysis of time-varying returns and volatility transmissions.

Table 8-3 documents the coefficients for the main GARCH-M models, using short- and long-term interest rates. Firstly, the linkage between volatility and the risk premia can be assessed by the coefficient of the GARCH term (θ_j) in the mean equation, which can be measured using the null hypothesis of $\theta_j = 0$ (H_1). The coefficient of GARCH term explains whether volatility is an influential factor on excess returns of REIT sub-sectors. The sign of the coefficient is determined by an investor's utility function (Engle *et al*., 1987). The coefficients of five out of six (office, retail, residential, specialty and diversified) J-REIT sub-sectors are not significant. The results contradict the findings of the majority of the early financial economics literature (Fama and Schwert, 1977; Campbell, 1987; French *et al*., 1987; Campbell and Hentschel, 1992; Glosten *et al*., 1993), but are consistent with the findings of a few financial economics literature studies (Baillie and DeGennaro, 1990) and the property literature (Stevenson *et al*., 2007; Lee *et al*., 2014; Akimov *et al*., 2020). This indicates the lack of a risk-return trade-off for five J-REIT sub-sectors over the study period, as noted by Elyasiani and Mansur (1998).

On the other hand, the coefficient of industrial REITs is significantly negative. As the volatility measured in the GARCH-M framework is a measure of total risk, rather than non-diversifiable systematic risk, the increase in volatility does not always come with an increase in the risk premium (Stevenson *et al*., 2007). This is reinforced by the findings of Elyasiani and Mansur (1998), in which volatility fluctuations among US banks could be largely unsystematic and attributable to movements in the flow of investments. Glosten *et al*. (1993) provide the reasons why the trade-off between risk and returns may be negative. Firstly, riskier periods may overlap with periods when investors can bear the risk. Secondly, if investors aim to hedge the total risk via investing in a less risky asset, competition may heighten the price of the asset and drop its risk premia. In this study, it can be argued that industrial REITs may be less affected by random shocks than the other assets in the marketplace, which leads investors to switch their investments to industrial REITs. The substitution process will result in a lower premium and a higher price level for industrial REITs. This is also supported by the lower correlation of stocks with industrial REITs (r = 0.40) than with the other J-REIT sub-sectors (average r = 0.56), as reported in Chapter 5. In short, the varying magnitude and direction of the trade-offs between excess returns and its conditional variance for all J-REIT sub-sectors are consistent with the financial economy and property literature, in which no consensus has been reached. Choudhry (1996) argues that the differences may depend on the influence of the crisis, movements towards privatisation, market-oriented policies and the market maturity of varying individual market involvements.

To examine the presence of ARCH and GARCH effects, hypothesis 2 ($\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$) was undertaken. The results refute the null hypothesis and present the volatility of excess returns as time-variant. Hypotheses 3 ($\theta_j = \beta_j = v_{1j} = v_{2j} = 0$), 4 ($\beta_j = v_{1j} = v_{2j} = 0$) and 5 ($\theta_j = v_{1j} = v_{2j} = 0$) measure whether the return generating process serves ARCH, ARCH-M and GARCH specifications, respectively. The results refute the null hypotheses. However, these findings ran counter to the initial results that the volatility does not significantly impact excess returns. Hypothesis 6

(v_{1j} = 0) examines whether market excess returns are a significant factor in excess returns and volatility of J-REIT sub-sectors. The inclusion of market excess returns produces a positive significant coefficient in the mean equation in each J-REIT sub-sector model over the entire study period. The conditional variance of excess market returns is generally significant in the variance equations in each J-REIT sub-sector model, except for residential and specialty REITs. This suggests that the overall equity market had a significant influence upon excess returns of six J-REIT sub-sectors.

The results generally provide weaker evidence of the sensitivity of sector-specific J-REITs to changes in interest rates than the previous REIT literature suggestions. The impact of interest rate level on REIT sub-sector excess returns can be estimated by the parameter μ_j. In terms of the sensitivity to 3-month interest rate changes, μ_j is not statistically different from zero for all J-REIT sub-sectors across these four markets, but is only significantly positive for industrial REITs. In terms of the sensitivity to 10-year interest rate movements, μ_j is only significantly positive for industrial, residential and diversified REITs. This indicates industrial, residential and diversified REITs were sensitive to changes in 10-year interest rates in the mean equation across the full study period, while industrial REITs was affected by changes in 3-month interest rates. The issue is the positive signs of the 3-month and 10-year interest rate series. This would suggest that there is a positive relationship between interest rates and excess returns. This is highly counterintuitive, due to the property literature affirming debt costs, yields and the general economic impact of interest rates on demand in the property sector (Bredin *et al.*, 2011). However, the results of the positive sign for industrial, residential and diversified REITs are consistent with the findings of Stevenson *et al*. (2007) and Lee *et al*. (2014), in which the positive significance of the interest rate sensitivity of the listed property markets in the USA, the UK, Germany and the Netherlands were documented during a period of lower interest rate volatility in these four markets. During the study period from 19 July 2006 to 31 December 2018, the historically low-interest rate investment environment in Japan may illustrate positive signs of the 10-year interest rate series for industrial, residential and diversified REITs, as well as that of 3-month interest rates for industrial REITs. Conversely, office, retail and specialty REITs were insignificant to both 3-month and 10-year interest rates.

Compared with the mean equation, the results provide weaker evidence of significance in the conditional volatility coefficients of interest rates for J-REIT sub-sectors in the variance equation. The impact of interest rate volatility on REIT sub-sector excess returns can be estimated by the parameter v_{2j}. This parameter is only significantly positive for diversified REITs. In other words, this section found only that the volatility of diversified REITs was positively affected by the conditional volatility of 3-month interest rates. However, sector-specific REITs were immune to changes in the conditional variance of both 3-month and 10-year interest rates. Following Liow and Huang (2006), the parameter β_j for all J-REIT sub-sectors was considerably larger than the values of α_j, providing evidence of the long memory of J-REIT sub-sectors.

The overall picture from these analyses is that while increases in 10-year interest rates were associated with higher excess returns for industrial, residential and diversified REITs, the increase in 3-month interest rates was only related to higher excess returns for industrial REITs. Furthermore, increases in 3-month interest rate volatility, as measured by changes in the conditional variance of the 3-month interest rate, were associated with higher excess returns for diversified REITs. On the other hand, excess returns for all property types of J-REITs remained unaffected when both 3-month and 10-year interest rates became more volatile in Japan. The lack of significance of the short- and long-term interest rate volatility effects on excess returns for all property types of J-REITs may indicate insignificant exposure to the interest rate risk owing to stronger risk aversion and hedging actions of different property types of J-REITs compared with their diversified counterparts over the entire sample period.

Table 8-3: GARCH-M model for Japan sector-specific REITs: July 2006–December 2018

	Diversified		**Office**		**Retail**	
	3M	10Y	3M	10Y	3M	10Y
Mean equation						
Const	−0.005(−0.207)	−0.023(−1.058)	−0.019(−0.634)	−0.024(−0.818)	−0.019(−0.600)	−0.019(−0.623)
Garch term	−0.017(−0.796)	−0.022(−1.142)	−0.025(−1.204)	−0.028(−1.377)	−0.020(−1.007)	−0.018(−1.177)
Market	0.315(33.752)***	0.288(27.773)***	0.363(32.337)***	0.363(32.345)***	0.329(26.707)***	0.327(26.556)***
IR	0.034(0.477)	0.065(2.367)**	0.014(0.165)	0.048(1.400)	0.135(1.192)	0.076(1.893)*
Variance equation						
Const	0.009(5.915)***	0.011(4.056)***	0.016(6.406)***	0.015(6.298)***	0.016(8.161)***	0.018(8.583)***
Arch	0.091(11.566)***	0.102(7.195)***	0.079(9.572)***	0.078(9.648)***	0.079(12.843)***	0.085(12.950)***
Garch	0.905(137.550)***	0.896(77.191)***	0.912(128.283)***	0.912(128.940)***	0.915(159.568)***	0.908(150.585)***
Market Vol	0.031(2.623)**	0.030(2.298)**	0.053(4.193)***	0.058(4.574)***	0.033(2.147)**	0.038(2.428)**
IR Vol	0.395(4.091)***	−44.349(−0.995)	0.689(0.402)	−71.348(−1.257)	1.087(0.411)	−45.618(−0.674)
	Industrial		**Residential**		**Specialty**	
Mean equation						
Const	0.060(1.960)**	−0.038(−1.302)	0.004(0.148)	−0.001(−0.038)	0.001(0.022)	0.001(0.078)
Garch term	−0.063(−2.983)***	−0.047(−2.497)**	−0.030(−1.237)	−0.027(−1.406)	−0.017(−0.896)	0.010(0.416)
Market	0.322(31.785)***	0.320(31.537)***	0.275(31.440)***	0.251(26.352)***	0.348(29.662)***	0.273(23.282)***
IR	0.442(3.559)***	0.152(3.602)***	0.041(0.548)	0.053(2.162)**	−0.005(−0.050)	0.013(0.471)
Variance equation						
Const	0.006(4.730)***	0.006(4.804)***	0.007(5.885)***	0.011(3.574)***	0.006(5.488)***	0.017(3.530)***
Arch	0.059(13.150)***	0.060(13.094)***	0.078(8.640)***	0.097(5.467)***	0.053(8.678)***	0.113(7.757)***
Garch	0.940(257.255)***	0.939(252.111)***	0.918(212.506)***	0.898(77.809)***	0.946(331.471)***	0.886(76.614)***
Market Vol	0.057(4.250)***	0.059(4.265)***	0.036(3.000)***	0.018(1.488)	0.044(2.868)***	0.007(0.456)
IR Vol	0.543(0.327)	−80.456(−1.179)	0.577(0.252)	−30.368(−0.784)	−0.211(−0.001)	−43.461(−0.780)

8.2.2 Sub-period Analysis

Table 8-4 presents summary statistics for excess returns of six J-REIT sub-sectors, as well as the statistics testing for normality over two sub-periods. Prior to the GFC, negative skewness is shown for office, retail, residential, specialty and diversified REITs, while positive skewness is presented for industrial REITs. Excess kurtosis is documented for all J-REIT sub-sector distributions. Post to the GFC, positive skewness is found for office, retail, residential and diversified REITs, whereas negative skewness is reported for industrial and specialty REITs. Excess kurtosis is discovered for all J-REIT sub-sector distributions. The level of volatility is exhibited for all J-REIT sub-sector series over two sub-periods, as presented in **Figure 8-4** and **Figure 8-5**. The fitness of the GARCH framework for six J-REIT sub-sector series is bolstered by **Figure 8-3**, depicting the ACF of both excess returns and the volatility, with the ACF displayed over 36 lags.

The unit root test was employed to verify whether the J-REIT sub-sector series were stationary in the level form or after first differencing. **Table 8-5** reports the results of ADF unit root test for excess returns of six J-REIT sub-sector series and the market equity index, as well as 3-month (IR 3m) and 10-year interest rate series (IR 10y) over two sub-periods: pre-GFC (Panel A) and post-GFC (Panel B), with the respective volatilities for market equity index, 3-month and 10-year interest rates. The pre-GFC results show that all variables were stationary at a 1% significance level without unit roots, except for the 3-month and 10-year interest rate series, as well as the conditional variance of the market excess return series. However, these three series refuted the null hypothesis of unit roots only after being restated in first differences. On the other hand, the post-GFC ADF unit root test results present the stationary at a 1% significance level without unit roots for all variables.

Table 8-4: Sub-period summary statistics for Japan sector-specific REITs

	Diversified		**Office**		**Retail**	
	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC
Mean(%)	0.107	0.045	0.145	0.043	0.060	0.045
Median(%)	0.125	0.021	0.106	0.014	0.013	0.016
Minimum(%)	5.910	8.397	5.745	6.443	5.406	8.773
Maximum(%)	−5.039	−8.878	−8.814	−8.549	−7.122	−8.588
Standard deviation(%)	1.469	1.019	1.639	1.137	1.651	1.251
Skewness	−0.118	0.049	−0.507	0.124	−0.244	0.430
Kurtosis	5.593	12.623	6.638	9.613	5.413	9.692
Jarque-Bera	81.076***	9,396.18***	170.600***	4,443.39***	72.469***	4,618.59***
	Industrial		**Residential**		**Specialty**	
Mean	0.100	0.058	0.069	0.053	0.060	0.069
Median	0.012	0.014	0.078	0.017	0.008	0.019
Minimum	8.503	6.241	4.398	8.137	4.987	5.974
Maximum	−8.169	−12.850	−4.648	−6.231	−5.713	−13.579
Standard deviation	2.329	1.131	1.162	0.951	1.427	1.187
Skewness	0.075	−0.228	−0.465	0.151	−0.130	−0.363
Kurtosis	4.790	13.598	5.359	10.771	5.410	13.018
Jarque-Bera	38.572***	11,416.80***	76.907***	6,136.12***	70.247***	10,236.15***

Table 8-6 tabulates the coefficients for the main GARCH-M model, using the short-term (3-month) and long-term (10-year) interest rates. Hypothesis 1 ($\theta_j = 0$) tests whether the volatility is a significant factor in excess returns of REIT sub-sectors. Prior to the GFC, the parameter θ_j was not significant for five out of six Japan REIT sub-sectors, while for residential REITs it was significantly negative. As previously discussed, the insignificant coefficients for office, retail, industrial, specialty and diversified REITs indicate the lack of a risk-return trade-off for these five Japan sub-sectors in the pre-GFC context, being consistent with the findings of Stevenson *et al*. (2007) and Lee *et al*. (2014). However, the significantly negative coefficients for residential REITs may be elucidated by the fact that residential REITs was less affected by the total risk than the other investment assets. This is generally strengthened by its comparatively low correlation with stocks ($r = 0.56$) in the pre-GFC context compared with the other J-REIT sub-sectors, as documented in Chapter 5.

Figure 8-4: Excess returns for Japan sector-specific REITs: pre-GFC: July 2006–September 2007

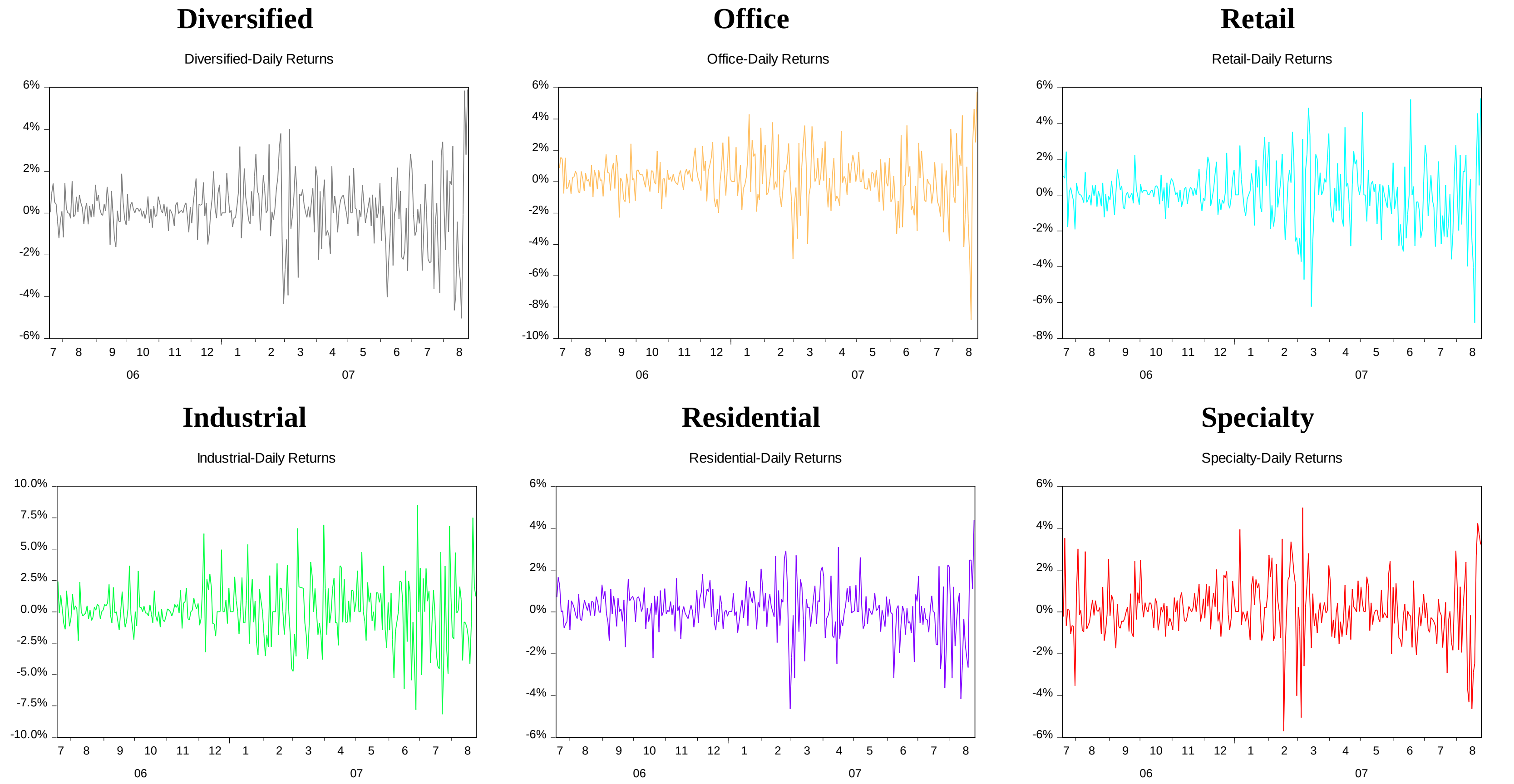


Figure 8-5: Excess returns for Japan sector-specific REITs: post-GFC: July 2009–December 2018

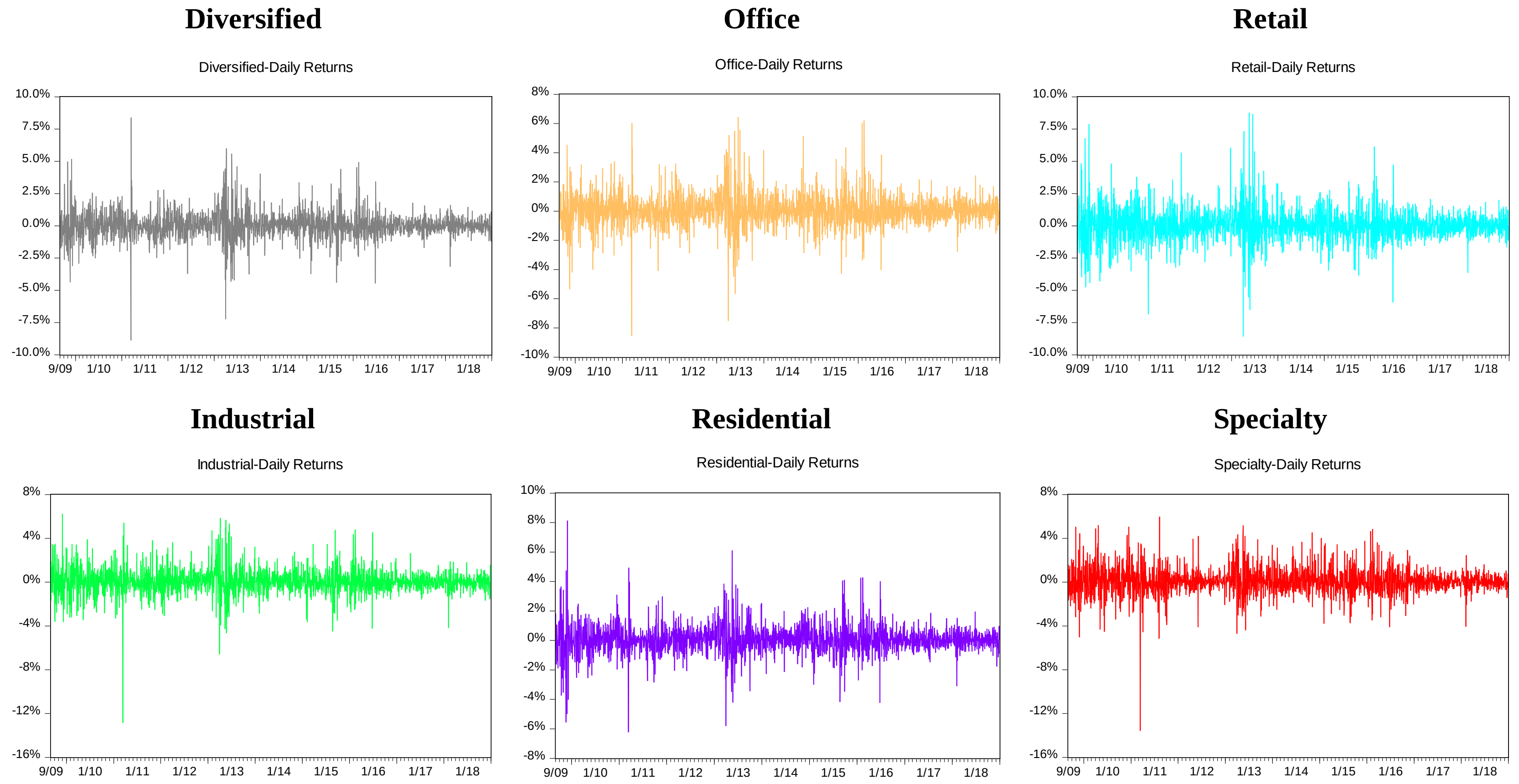


Table 8-5: Sub-period ADF unit test for Japan sector-specific REITs

Variable	Level		First differences		Stationary
	t-statistics	*p*-value	*t*-statistics	*p*-value	
Panel A: Pre-GFC: July 2006–September 2007					
Diversified	−13.534	0.000	−10.002	0.000	$I(0)$
Office	−14.681	0.000	−10.334	0.000	$I(0)$
Retail	−14.110	0.000	−10.333	0.000	$I(0)$
Industrial	−17.598	0.000	−9.694	0.000	$I(0)$
Residential	−14.877	0.000	−11.508	0.000	$I(0)$
Specialty	−15.411	0.000	−9.228	0.000	$I(0)$
Market	−17.311	0.000	−10.675	0.000	$I(0)$
IR 3m	−2.132	0.525	−14.100	0.000	$I(1)$
IR 10y	−2.271	0.182	−19.238	0.000	$I(1)$
Market Vol.	−1.801	0.380	−16.806	0.000	$I(1)$
IR 3m Vol.	−16.656	0.000	−16.607	0.000	$I(0)$
IR 10y Vol.	−3.904	0.013	−28.153	0.000	$I(0)$
Panel B: Post-GFC: July 2009–December 2018					
Diversified	−44.976	0.000	−20.268	0.000	$I(0)$
Office	−45.901	0.000	−20.375	0.000	$I(0)$
Retail	−28.143	0.000	−20.329	0.000	$I(0)$
Industrial	−45.505	0.000	−20.363	0.000	$I(0)$
Residential	−44.312	0.000	−19.222	0.000	$I(0)$
Specialty	−45.343	0.000	−20.323	0.000	$I(0)$
Market	−49.221	0.001	−21.935	0.000	$I(0)$
IR 3m	−6.000	0.000	−16.513	0.000	$I(0)$
IR 10y	−1.923	0.005	−48.520	0.001	$I(0)$
Market Vol.	−9.515	0.000	−6.458	0.000	$I(0)$
IR 3m Vol.	−44.282	0.001	−21.586	0.000	$I(0)$
IR 10y Vol.	−5.271	0.000	−43.866	0.000	$I(0)$

Note: H_0-non-stationary

The pre-GFC results provide strong evidence of the 10-year interest rate sensitivity of all J-REIT sub-sectors, being highly consistent with the mainstream property literature in which the parameters on interest rates are inversely related to excess returns of composite REITs. On the other hand, the results report no significant evidence for the sensitivity of all J-REIT sub-sectors to the 3-month interest rate series. However, changes in the conditional variance of 3-month interest rates were documented to have a positive influence on excess returns for diversified REITs. In contrast, there was no significant sign for the other sector-specific REITs. These findings generally imply that fluctuations in the conditional variance of 3-month interest rates had a significant impact upon excess returns of diversified REITs in the pre-GFC investment context, rather than sector-specific REITs. The insignificance of the short- and long-term interest rate volatility effects on excess returns for all property types of REITs may indicate that sector-specific REITs were less sensitive to the 3-month and 10-year interest rate risks than diversified REITs in the pre-GFC investment context.

Post to the GFC, the trade-offs between excess returns and the conditional variance were significantly negative for industrial and specialty REITs, evident by the negative value of the parameter θ_j in the mean equation. These results signify that both industrial and specialty REITs were less influenced by the total risk in the marketplace than the other investment assets in the post-GFC investment context. This can be supported by the lowest and second-lowest correlations with stocks for both industrial ($r = 0.43$) and specialty REITs ($r = 0.45$), respectively, as presented in the sub-period analysis in Chapter 5. On the other hand, the parameter θ_j was insignificant for office, retail, residential and diversified REITs, implying that these four J-REIT sub-sectors lacked a risk-return trade-off in the post-GFC context. An interesting finding is that the post-GFC J-REIT sub-sectors were highly influenced by excess returns and the volatility of the market equity compared with their pre-GFC levels, rejecting the null hypothesis of $v_{1j} = 0$ (H_6). This is evident in the fact that the addition of market excess returns and the volatility presented the positive significant coefficients in both the mean and variance equations in each J-REIT sub-sector model in the post-GFC context. However, excess returns of few J-REIT sub-sector were affected by the conditional variance of the market equity index prior to the GFC.

The post-GFC results show that changes in 3-month interest rates were positively related to excess returns for retail, industrial, residential and specialty REITs. Meanwhile, changes in 10-year interest rates were positively associated with excess returns for industrial and specialty REITs. The results suggest that there was a positive relationship between interest rates and excess returns for J-REIT sub-sectors. This contrasts starkly with mainstream property literature's assertion of the property sector's being highly susceptible to interest rate movements. This is related to the high levels of borrowing and the influence of interest rate changes on property yields, occupational demand and rental income for the conventional property sector (Bredin *et al.*, 2011). This can be elucidated by the historically low interest rate environment in the post-GFC context, stimulated by QE across many central banks in the international context. However, there is no evidence of the sensitivity of excess returns for diversified and office REITs to changes in either the 3-month or 10-year interest rate series. There is also no evidence on significance in the conditional volatility coefficients of interest rates for any J-REIT sub-sector in the variance equation in the post-GFC context. The post-GFC analysis suggests that 3-month interest rate movements affected excess returns of retail, industrial, residential and specialty REITs. At the same time, changes in the 10-year interest rate series had a significant impact on industrial and specialty REITs. Excess returns of all J-REIT sub-sectors were not influenced by changes in the conditional variance of either the 3-month or the 10-year interest rate series. Following Liow and Huang (2006), the parameter β_j for all J-REIT sub-sectors was considerably larger than the values of α_j, providing evidence for the long memory of J-REIT sub-sectors over the two sub-periods.

The overall picture from these analyses suggests that movements in the post-GFC 3-month interest rate series had a significant influence on four of J-REIT sub-sectors, namely retail, industrial, residential and specialty REITs. Changes in the pre-GFC 10-year interest rate series affected all J-REIT sub-sectors in the pre-GFC context. Diversified J-REITs was found to be influenced by movements in the conditional variance of 3-month interest rates before the GFC, while all property types of J-REITs were immune to changes in both 3-month and 10-year interest rates after the GFC. This implies that sector-specific REITs were less sensitive to changes in short- and long-term interest rates than diversified REITs prior to the GFC. There were no differences between sector-specific and diversified REITs in the post-GFC context.

Table 8-6: Sub-period GARCH-M model for Japan sector-specific REITs

	Pre-GFC: July 2006−September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel A: Diversified				
Mean equation				
Const	−0.300(−0.729)	3.152(2.665)***	−0.038(−1.285)	−0.024(−0.878)
Garch term	−0.118(−1.372)	−0.056(−0.860)	−0.034(−0.954)	0.025(0.671)
Market	0.307(4.970)***	0.307(5.012)***	0.280(28.088)***	0.279(28.018)***
IR	0.783(1.061)	−1.827(−2.580)***	0.148(1.281)	0.043(1.296)
Variance equation				
Const	0.041(1.958)*	0.043(2.134)**	0.011(5.454)***	0.011(5.448)***
Arch	0.223(3.832)***	0.259(3.718)***	0.081(11.291)***	0.081(11.311)***
Garch	0.775(14.569)***	0.733(12.203)***	0.906(106.448)***	0.906(105.725)
Market Vol	0.138(0.965)	0.079(0.478)	0.046(3.647)**	0.048(3.718)**
IR Vol	0.382(2.266)**	125.039(0.646)	1173.175(0.497)	−40.191(−0.594)
Panel B: Office				
Mean equation				
Const	0.594(1.189)	3.691(2.668)***	−0.043(−1.125)	−0.028(−0.799)
Garch term	0.143(0.892)	−0.111(−0.866)	−0.054(−1.542)	−0.037(−0.954)
Market	0.405(5.347)***	0.372(5.038)***	0.305(27.615)***	0.304(27.524)***
IR	−0.922(−1.030)	−2.134(−2.628)***	0.101(0.807)	0.026(0.724)
Variance equation				
Const	0.032(1.214)	0.036(1.036)	0.025(5.727)***	0.025(5.735)***
Arch	0.128(2.851)***	0.156(3.125)***	0.082(9.106)***	0.083(9.129)***
Garch	0.871(21.767)***	0.831(16.846)***	0.893(74.273)***	0.892(73.478)***
Market Vol	−0.004(−0.035)	0.230(1.161)	0.070(5.338)***	0.072(5.399)***
IR Vol	0.701(0.280)	−86.848(−0.374)	1399.017(0.527)	−73.107(−0.853)

Table 8-6: Sub-period GARCH-M model for Japan sector-specific REITs (Cont1)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel C: Retail				
Mean equation				
Const	1.006(1.667)*	3.489(2.782)***	−0.057(−1.446)	−0.038(−1.089)
Garch term	0.092(0.905)	−0.038(−0.690)	−0.011(−0.424)	−0.007(−0.235)
Market	0.242(3.520)***	0.204(2.820)***	0.281(22.190)***	0.280(22.079)***
IR	−1.592(−1.255)	−1.980(−2.791)***	0.271(1.795)*	0.070(1.582)
Variance equation				
Const	0.009(0.791)	0.014(0.873)	0.040(7.811)***	0.040(7.882)***
Arch	0.087(3.127)***	0.141(3.357)***	0.118(10.035)***	0.120(10.027)***
Garch	0.905(31.000)***	0.854(22.785)***	0.854(65.478)***	0.852(65.148)***
Market Vol	−0.222(−1.741)*	0.088(0.443)	0.037(2.226)**	0.039(2.336)**
IR Vol	1.134(0.614)	0.862(0.004)	2122.787(0.566)	−4.819(−0.054)
Panel D: Industrial				
Mean equation				
Const	−0.877(−1.258)	7.502(4.482)***	−0.079(−2.168)**	−0.043(−1.306)
Garch term	−0.045(−0.804)	0.001(0.042)	−0.074(−1.843)*	−0.068(−1.562)
Market	0.209(2.471)**	0.203(2.531)**	0.302(27.713)***	0.301(27.474)***
IR	2.053(1.354)	−4.409(−4.393)***	0.519(3.253)***	0.156(3.246)***
Variance equation				
Const	0.095(2.251)**	0.098(1.639)	0.008(5.456)***	0.008(5.473)***
Arch	0.152(3.302)***	0.230(3.571)***	0.054(10.414)***	0.054(10.377)***
Garch	0.846(20.602)***	0.760(15.214)***	0.940(210.328)***	0.940(208.355)***
Market Vol	0.127(0.747)	0.254(1.296)	0.063(4.404)***	0.068(4.648)***
IR Vol	0.532(0.108)	73.654(0.272)	2362.903(0.858)	−54.296(−0.636)

Table 8-6: Sub-period GARCH-M model for Japan sector-specific REITs (Cont2)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel E: Residential				
Mean equation				
Const	0.398(1.280)	3.611(3.292)***	−0.044(−1.409)	−0.023(−0.829)
Garch term	−0.083(−0.521)	−0.360(−2.135)**	−0.001(−0.239)	0.003(0.072)
Market	0.393(6.055)***	0.387(6.394)***	0.237(24.841)***	0.236(24.538)***
IR	−0.609(−1.027)	−2.025(−3.120)***	0.200(1.798)*	0.049(1.515)
Variance equation				
Const	0.090(2.042)**	0.081(2.072)**	0.018(5.517)***	0.019(5.558)***
Arch	0.130(2.501)**	0.114(2.520)**	0.114(9.431)***	0.118(9.233)***
Garch	0.784(9.297)***	0.799(10.538)***	0.862(67.392)***	0.859(65.955)***
Market Vol	0.055(0.573)	0.182(1.645)*	0.038(2.879)**	0.040(2.955)**
IR Vol	0.582(0.034)	58.246(0.267)	2338.009(1.016)	−23.882(−0.405)
Panel F: Specialty				
Mean equation				
Const	0.130(0.383)	3.474(2.981)***	−0.042(−1.141)	−0.022(−0.681)
Garch term	−0.056(−0.634)	−0.080(−0.920)	−0.060(−1.711)*	−0.069(−1.616)
Market	0.432(6.145)***	0.400(5.860)***	0.314(25.805)***	0.314(25.707)***
IR	−0.715(−1.300)	−2.127(−3.230)***	0.364(2.332)**	0.121 (2.574)**
Variance equation				
Const	0.135(1.951)*	0.092(1.776)*	0.002(3.344)***	0.002(3.247)***
Arch	0.201(3.735)***	0.180(3.487)***	0.027(7.184)***	0.027(7.150)***
Garch	0.720(9.295)***	0.767(11.654)***	0.972(374.415)***	0.972(371.250)***
Market Vol	0.352(2.550)**	0.232(1.453)	0.053(3.710)***	0.055(3.798)***
IR Vol	−0.283(−0.005)	122.251(0.525)	599.265(0.352)	13.672(0.136)

8.3 INTEREST RATE SENSITIVITY OF SECTOR-SPECIFIC REITs IN AUSTRALIA

8.3.1 GARCH-M Specification

Table 8-8 details the descriptive statistics of daily excess returns for Australian sector-specific and diversified REITs from 19 July 2006 to 31 December 2018, as well as the measure for the skewness, kurtosis and Jarque-Bera normality tests applied on the excess return series. Negative skewness is displayed for office, retail, industrial, specialty and diversified REITs, whereas positive skewness is only exhibited for residential REITs. All A-REIT sub-sector distributions show excess kurtosis. Based on the Jarque-Bera statistics, the null hypothesis of a normal distribution is rejected for all A-REIT sub-sectors. The dynamics of 3-month and 10-year interest rates are presented in **Figure 8-6**. The plots of daily excess returns for each A-REIT sub-sector over the full study period are displayed in **Figure 8-7**. A high level of volatility for all A-REIT sub-sector series was witnessed. The time-varying characteristics with the volatility clustering evidence for each A-REIT sub-sectors imply the fitness of the GARCH approach to model excess returns of A-REIT sub-sectors. **Figure 8-8** depicts the ACF of both excess returns and the volatility for all A-REIT sub-sectors, with the ACF displayed over 36 lags. The results indicate the existence of ARCH effects on daily excess REIT returns for each A-REIT sub-sectors. This is also confirmed by the LM tests, as shown in **Table 8-6**. This validates the suitability of the GARCH framework for each A-REIT sub-sector series over the entire study period.

Table 8-7: ADF unit test for Australian sector-specific REITs: July 2006–December 2018

Variable	Level		First differences		Stationary
	t-statistics	*p*-value	*t*-statistics	*p*-value	
Diversified	−35.006	0.000	−21.545	0.000	*I*(0)
Office	−34.930	0.000	−23.292	0.000	*I*(0)
Retail	−28.080	0.000	−19.812	0.000	*I*(0)
Industrial	−53.827	0.000	−24.581	0.000	*I*(0)
Residential	−54.448	0.000	−20.533	0.000	*I*(0)
Specialty	−62.845	0.000	−21.627	0.000	*I*(0)
Market	−58.165	0.000	−23.129	0.000	*I*(0)
IR 3m	−1.853	0.006	−40.197	0.000	*I*(0)
IR 10y	−1.392	0.153	−58.907	0.000	*I*(1)
Market Vol.	−6.528	0.000	−17.436	0.000	*I*(0)
IR 3m Vol.	−10.397	0.000	−17.861	0.000	*I*(0)
IR 10y Vol.	−3.545	0.007	−12.041	0.000	*I*(0)

Note: H_0-non-stationary

Table 8-8: Summary statistics for Australian sector-specific REITs: July 2006–December 2018

	Diversified	**Office**	**Retail**	**Industrial**	**Residential**	**Specialty**
Mean	0.020	0.033	0.021	0.023	0.027	0.027
Median	0.029	0.041	0.018	0.027	0.020	0.040
Maximum	9.805	9.968	6.833	8.454	20.128	11.819
Minimum	−12.744	−18.296	−6.740	−16.039	−14.978	−7.682
Standard deviation	1.519	1.423	0.925	1.242	1.839	1.056
Skewness	−0.238	−1.181	−0.147	−1.102	0.850	−0.063
Kurtosis	13.057	20.556	11.416	17.540	23.831	16.163
Jarque-Bera	13,722.29***	42,477.50***	9,600.61***	29,275.20***	59,134.41***	23,459.12***
LM test	324.477***	437.973***	591.576***	143.840***	169.089***	130.548***

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

Table 8-7 reports the results of unit root tests using the ADF test on the level and first differences for all A-REIT sub-sectors, the market equity index and the 3-month and 10-year interest rate series over the full study period, as well as the conditional variances of the market equity index and 3-month and 10-year interest rates. In level form, the null hypothesis of unit roots was refuted by all variables except the 10-year interest rate series. When the 10-year interest rate series were transformed into first differences, the ADF test results indicate a rejection of the null hypothesis at a 1% significance level. **Table 8-9** tabulates the coefficients for the main GARCH model over the full study period, using both the 3-month and 10-year interest rate series. Firstly, the coefficient on the GARCH term (θ_j) in the mean equation describes the trade-off between excess returns and the conditional variance of A-REIT sub-sectors, as measure by $\theta_j = 0$ (H_1). In the 3-month interest rate model, the influence of volatility on excess returns was found to be negative but insignificant for retail, specialty and diversified REITs over the full study period, while it was positive but insignificant for office, industrial and residential REITs. In the 10-year interest rate model, the parameter θ_j was reported to be negative but insignificant for retail and diversified REITs, while that for office, industrial, residential and specialty REITs was positive but insignificant. The insignificant results for all A-REIT sub-sector imply the lack of a risk-return trade-off for all A-REIT sub-sectors over the entire study period. The varying magnitude of the GARCH term coefficient is consistent with the property literature, in which no consensus has been reached on the direction and magnitude of the trade-off between excess returns and the conditional variance of stocks, property and REITs.

Figure 8-6: 3-month and 10-year interest rates in Australia: July 2006–December 2018

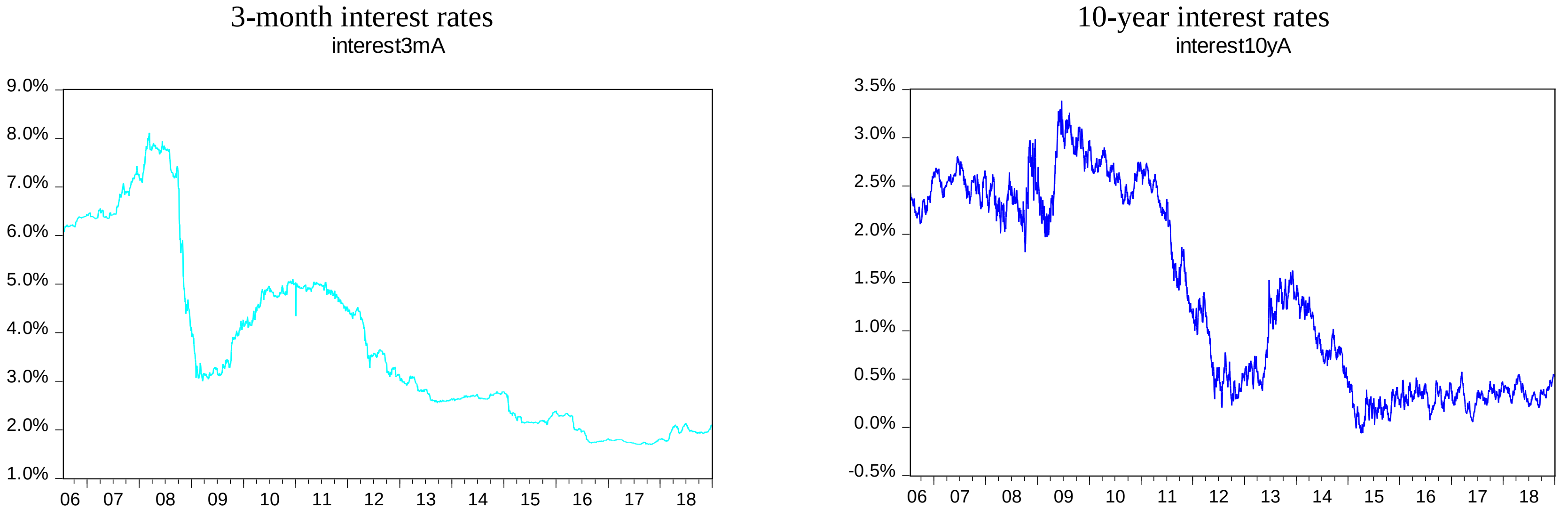


Figure 8-7: Excess returns for Australian sector-specific REITs: July 2006–December 2018

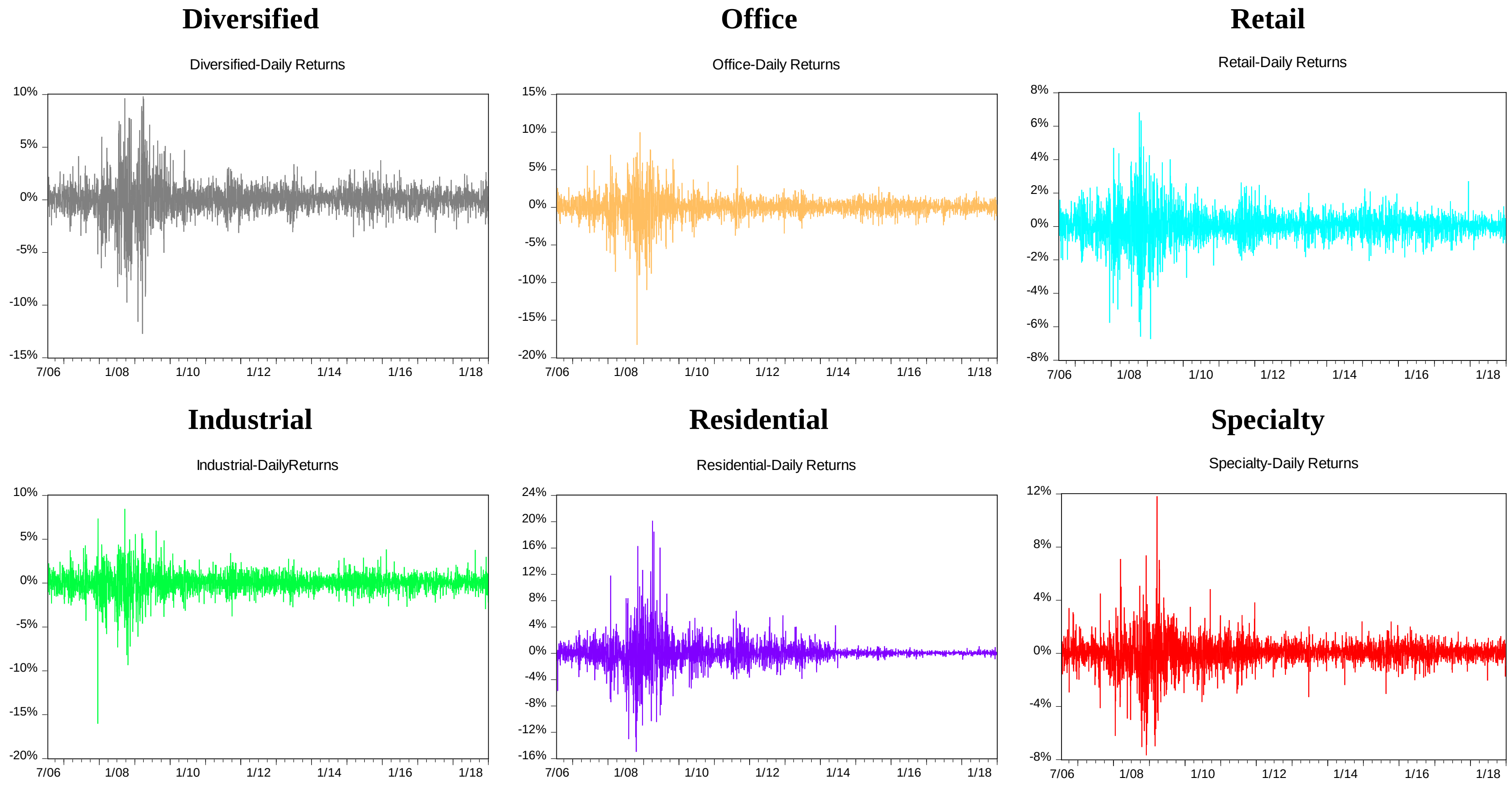
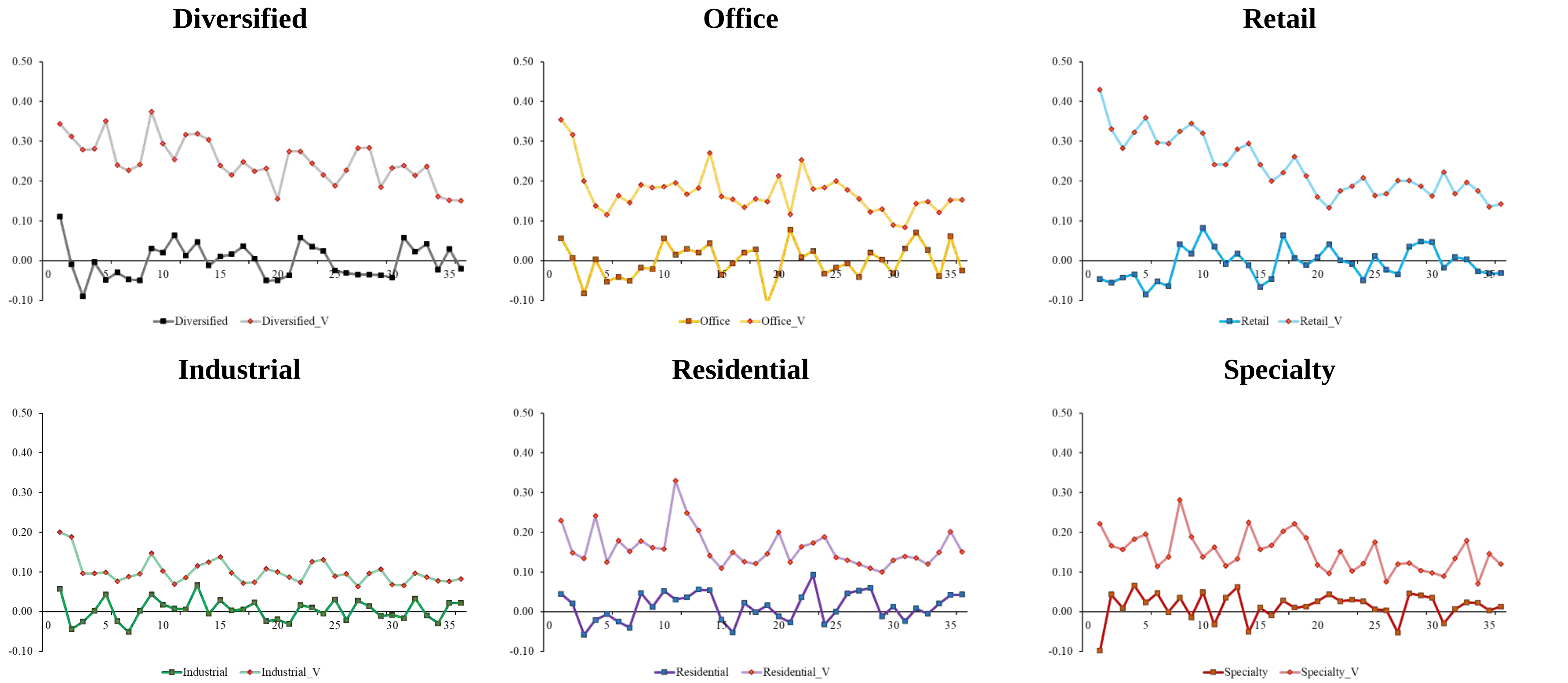


Figure 8-8: Autocorrelation plots for excess returns and volatility of Australian sector-specific REITs: July 2006–December 2018



Hypothesis 2 ($\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$) examines the presence of ARCH and GARCH effects. The results reject the null hypothesis and indicate that the volatility of excess returns was time-variant. To measure whether the return-generating process serves ARCH, ARCH-M and GARCH specifications, hypothesis 3 ($\theta_j = \beta_j = v_{1j} = v_{2j} = 0$), 4 ($\beta_j = v_{1j} = v_{2j} = 0$) and 5 ($\theta_j = v_{1j} = v_{2j} = 0$) were tested respectively. The results reject the null hypotheses. However, these findings contradict the initial results that volatility is not a significant factor in excess returns. According to the assumption $v_{1j} = 0$ (H_6), the inclusion of market excess returns generally exhibits positive significant coefficients in the mean equation for all A-REIT sub-sectors over the entire study period. Changes in the market volatility, as conducted by the conditional variance of excess returns for the equity index, were insignificant to excess returns of all A-REIT sub-sectors, except for industrial REITs, which had a negative sign at a 10% significance level. In other words, industrial REITs may be inversely affected by the volatility of the overall stock markets compared with the other sector-specific REITs and diversified REITs over the full sample period.

The estimates of changes in the interest rate level and volatility on excess returns for All A-REIT sub-sectors are also reported in **Table 8-9**. The results show stronger evidence for the variance equation than for the mean equation in the Australian context. Specifically, excess returns of diversified REITs were documented to be negatively affected by 10-year interest rates at a 10% significance level over the full sample period. Meanwhile, different property types of REITs were unaffected by fluctuations in either the 3-month or 10-year interest rate series. An increase in 10-year interest rates was thus associated with lower excess returns for diversified REITs. The impact of changes in both 3-month and 10-year interest rates on excess returns was negligible for all sector-specific A-REITs.

In terms of the impact of the conditional variance of 3-month and 10-year interest rates on excess returns for A-REIT sub-sectors, office REITs was positively influenced by changes in 3-month interest rates over the entire study period, while retail, residential and diversified REITs were positively affected by movements in 10-year interest rates. These were the same in direction but different in magnitude across these four A-REIT sub-sectors. Industrial and specialty REITs were insignificantly affected by changes in both the 3-month and 10-year interest rate series. Since the parameter β_j for all A-REIT sub-sectors was considerably larger than the value of α_j, there was some evidence for the long memory of A-REIT sub-sectors.

The overall picture from the analyses in this section is that increases in 10-year interest rate levels were associated with lower excess returns for diversified REITs. However, all property types of A-REITs were unaffected by increases in either 3-month or 10-year interest rate levels. Additionally, increases in the 10-year interest rate volatility, as estimated by the conditional variance of the 10-year interest rate series, were highly associated with the higher excess returns of retail, residential and diversified REITs. Similarly, increases in 3-month interest volatility were related to higher excess returns for office REITs. The insignificance of the short- and long-term interest rate volatility effects on excess returns for industrial and specialty REITs may imply that these two sector-specific REITs are less sensitive to short- and long-term interest rate risk than the other sector-specific and diversified REITs.

Table 8-9: GARCH-M model for Australian sector-specific REITs: July 2006–December 2018

	Diversified		**Office**		**Retail**	
	3M	10Y	3M	10Y	3M	10Y
Mean equation						
Const	0.072(2.309)**	0.046 (1.827)*	0.055(2.002)**	0.039(1.745)*	0.012(0.623)	0.011(0.685)
Garch term	−0.004(−0.226)	−0.007(−0.347)	0.010(0.488)	0.006 (0.297)	−0.068(−1.802)	−0.082(−2.122)**
Market	0.686(47.749)***	0.686(47.714)***	0.544(42.621)***	0.544(42.593)***	0.431(45.265)***	0.431(45.195)***
IR	−0.013(−1.548)	−0.028(−1.941)*	−0.008(−0.994)	−0.012(−0.906)	0.001(0.234)	−0.005(−0.444)
Variance equation						
Const	0.007(3.276)***	0.007(3.289)***	0.004(3.309)***	0.004(3.296)***	0.002(2.414)**	0.002(2.424)**
Arch	0.043(4.173)***	0.043(4.179)***	0.038(4.441)***	0.038(4.430)***	0.038(3.899)***	0.038(3.873)***
Garch	0.950(122.639)***	0.950(123.016)***	0.956(147.160)***	0.957(148.170)***	0.958(144.446)***	0.959(145.552)***
Market Vol	−0.007(−0.351)	−0.024(−1.125)	−0.003(−0.156)	−0.014(−0.700)	0.023(1.525)	0.018(1.179)
IR Vol	0.529(1.782)*	19.413(2.203)**	0.594(1.645)*	11.246(1.123)	0.209(0.644)	12.064(2.244)**
	Industrial		**Residential**		**Specialty**	
Mean equation						
Const	0.086(2.861)***	0.065(2.663)***	0.018(0.918)	0.009(0.595)	0.086(3.799)***	0.075(4.262)***
Garch term	0.021(0.660)	0.018(0.530)	0.003(0.294)	0.007(0.529)	−0.000(−0.014)	0.006(0.188)
Market	0.553(39.158)***	0.553(39.139)***	0.076(9.431)***	0.082(9.169)***	0.198(16.434)***	0.198(16.385)***
IR	−0.012(−1.381)	−0.018(−1.257)	0.006(0.741)	0.017(1.014)	−0.007(−1.009)	−0.021(−1.624)
Variance equation						
Const	0.006(3.227)***	0.006(3.211)***	0.000(1.805)*	0.000(3.619)***	0.002(4.224)***	0.002(4.215)***
Arch	0.043(6.532)***	0.042(6.512)***	0.034(6.703)***	0.049(9.803)***	0.034(7.603)***	0.034(7.541)***
Garch	0.950(129.388)***	0.950(130.379)***	0.961(188.732)***	0.950(316.252)***	0.964(275.011)***	0.964(279.901)***
Market Vol	−0.038(−1.709)*	−0.044(−1.936)*	−0.022(−1.441)	−0.018(−1.211)	−0.020(−1.210)	−0.027(−1.609)
IR Vol	0.009(0.027)	5.393(0.467)	−0.362(−0.584)	21.881(2.205)**	0.112(0.192)	7.066(0.905)

8.3.2 Sub-period Analysis

Table 8-8 lists summary statistics for excess returns of six A-REIT sub-sectors, as well as the statistics testing for normality over two sub-periods. Before the GFC, the daily risk-return ranking for all A-REIT sub-sectors is inconsistent with the pre-GFC results in Chapter 5. The differences could be explained by the varying frequency of excess return series for all A-REIT sub-sectors. Negative skewness is witnessed for all A-REIT sub-sectors, except for specialty REITs. All A-REIT sub-sector distributions presented excess kurtosis, while the Jarque-Bera statistics disprove a normal distribution for all A-REIT sub-sectors. After the GFC, the risk-return rankings for all A-REIT sub-sectors are highly consistent with the post-GFC risk-return profiles results in Chapter 5. Positive skewness is exhibited for all A-REIT sub-sectors, except for specialty REITs. All A-REIT sub-sector distributions exhibit excess kurtosis. The Jarque-Bera statistics disprove a normal distribution for all A-REIT sub-sectors. The plots of daily excess returns for each A-REIT sub-sector series over two sub-periods are exhibited in **Figure 8-9** and **Figure 8-10**, respectively. The suitability of the GARCH framework for all A-REIT sub-sector series is reinforced by **Figure 8-8**, in which the ACF tests of both excess returns and the volatility of A-REIT sub-sectors are presented, with the ACF displayed over 36 lags.

Table 8-7 summarises the findings of the ADF unit root test for all A-REIT sub-sectors and market equity index, as well as 3-month (IR 3m) and 10-year interest rate series (IR 10y) over the pre-GFC (Panel A) and post-GFC periods (Panel B), with the respective volatilities for market equity index and the 3-month and 10-year interest rates. Prior to the GFC, the ADF tests on the level form show that the computed t-statistics for all A-REIT sub-sectors, market equity index and the 10-year interest rate volatility did not indicate the presence of unit root. The exceptions are the 3-month and 10-year interest rate series, and the conditional variances of market equity index and 3-month interest rates. The ADF test was extended on the first differences for all variables, resulting in all variables strongly rejected the null hypothesis at a 1% significance level. This showed the first difference between 3-month and 10-year interest rate series, the market equity volatility and 3-month interest rate volatility. Post to the GFC, most of the variables did not have the unit root. The only exception is the 3-month interest rate series. However, it rejected the null hypothesis of unit roots only after being restated in first differences. This saw the first difference in 3-month interest rates. Overall, all series are suitable for further analysis of time-varying return and volatility transmissions over two sub-period timeframes.

Table 8-7: Sub-period ADF unit test for Australian sector-specific REITs

Variable	Level		First differences		Stationary
	t-statistics	*p*-value	*t*-statistics	*p*-value	
Panel A: Pre-GFC: July 2006–September 2007					
Diversified	−13.980	0.000	−10.354	0.000	$I(0)$
Office	−15.366	0.000	−15.788	0.000	$I(0)$
Retail	−17.825	0.000	−9.870	0.000	$I(0)$
Industrial	−13.263	0.000	−10.159	0.000	$I(0)$
Residential	−14.182	0.000	−15.665	0.000	$I(0)$
Specialty	−16.708	0.000	−12.566	0.000	$I(0)$
Market	−19.128	0.000	−11.532	0.000	$I(0)$
IR 3m	2.347	0.996	−14.748	0.000	$I(1)$
IR 10y	−0.047	0.666	−17.167	0.000	$I(1)$
Market Vol.	1.775	1.000	−1.822	0.065	$I(1)$
IR 3m Vol.	0.425	0.805	−9.712	0.000	$I(1)$
IR 10y Vol.	−7.344	0.000	−4.855	0.000	$I(0)$
Panel B: Post-GFC: July 2009–December 2018					
Diversified	−49.882	0.000	−18.777	0.000	$I(0)$
Office	−51.138	0.000	−19.810	0.000	$I(0)$
Retail	−38.566	0.000	−21.882	0.000	$I(0)$
Industrial	−52.046	0.000	−20.568	0.000	$I(0)$
Residential	−50.189	0.000	−25.044	0.000	$I(0)$
Specialty	−56.073	0.000	–23.477	0.000	$I(0)$
Market	−48.964	0.000	−20.419	0.000	$I(0)$
IR 3m	−1.022	0.276	−25.779	0.000	$I(1)$
IR 10y	−2.249	0.024	−49.988	0.000	$I(0)$
Market Vol.	−5.550	0.000	−50.228	0.000	$I(0)$
IR 3m Vol.	−9.169	0.000	−16.738	0.000	$I(0)$
IR 10y Vol.	−4.071	0.001	−31.136	0.000	$I(0)$

Note: H_0-non-stationary

Table 8-8: Sub-period summary statistics for Australian sector-specific REITs

	Diversified		Office		Retail	
	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC
Mean(%)	−0.209	0.042	−0.085	0.055	−0.039	0.028
Median(%)	−0.061	0.030	−0.039	0.042	0.020	0.017
Minimum(%)	7.472	5.103	6.976	6.418	4.700	2.698
Maximum(%)	−8.294	−5.044	−8.582	−4.692	−5.769	−3.080
Standard deviation(%)	2.223	0.896	2.124	0.849	1.445	0.623
Skewness	−0.087	0.119	−0.198	0.066	−0.224	0.174
Kurtosis	5.077	4.759	4.762	7.421	4.549	4.602
Jarque-Bera	51.95***	9319.66***	39.00***	1,984.95***	31.09***	272.71***
	Industrial		**Residential**		**Specialty**	
Mean	−0.138	0.055	−0.364	0.050	−0.187	0.062
Median	0.015	0.027	−0.300	0.020	−0.070	0.046
Minimum	7.344	4.853	11.801	6.439	7.097	4.820
Maximum	−16.039	−3.857	−13.047	−6.538	−6.219	−3.669
Standard deviation	2.144	0.845	2.493	1.052	1.449	0.719
Skewness	−1.461	0.082	−0.087	0.307	0.189	−0.098
Kurtosis	13.366	4.558	8.204	8.879	6.986	6.505
Jarque-Bera	1,387.15***	249.01***	324.26***	3,544.65***	191.67***	1,250.50***

Figure 8-9: Excess returns for Australian sector-specific REITs: pre-GFC: July 2006–September 2007

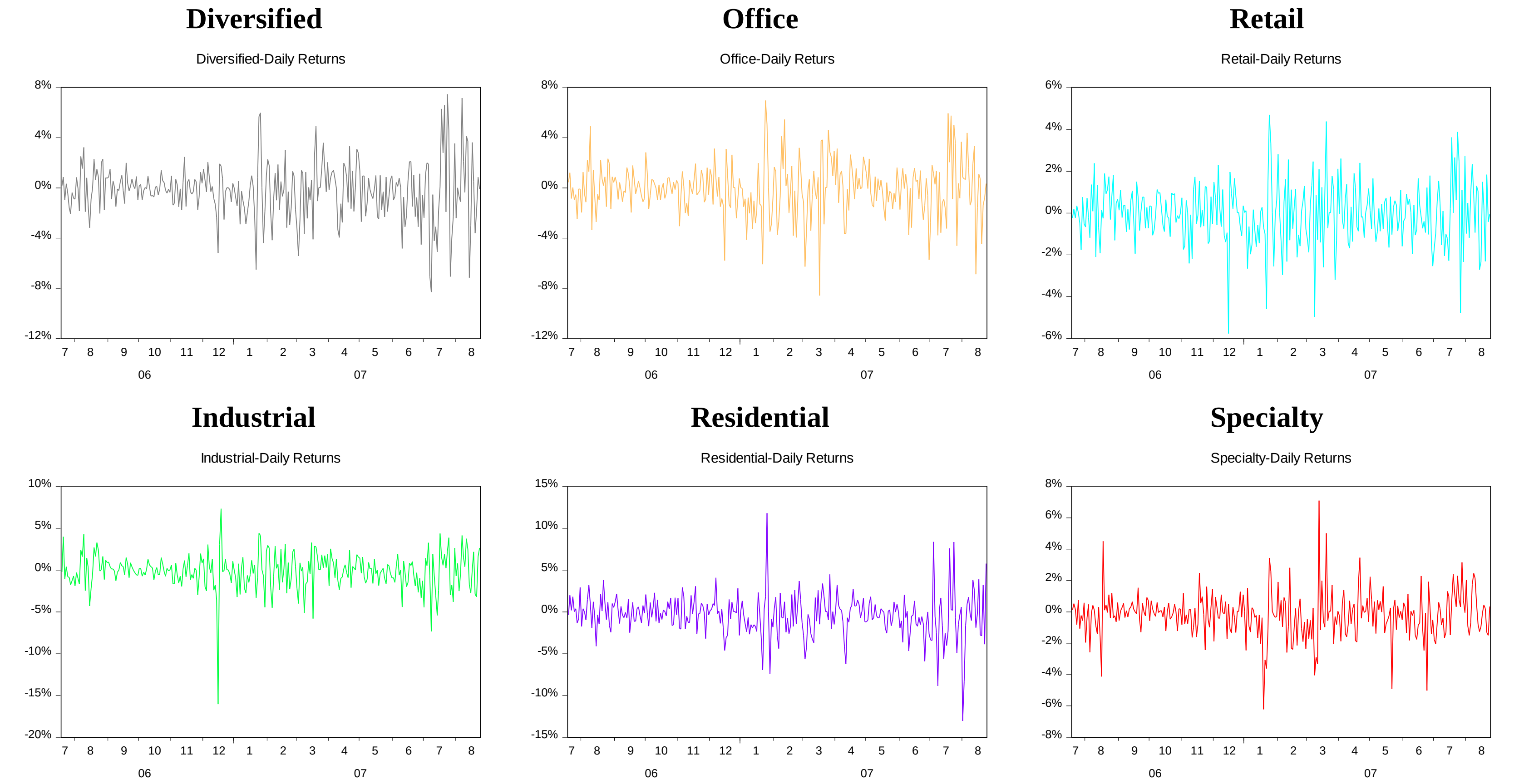


Figure 8-10: Excess returns for Australian sector-specific REITs: post-GFC: July 2009–December 2018

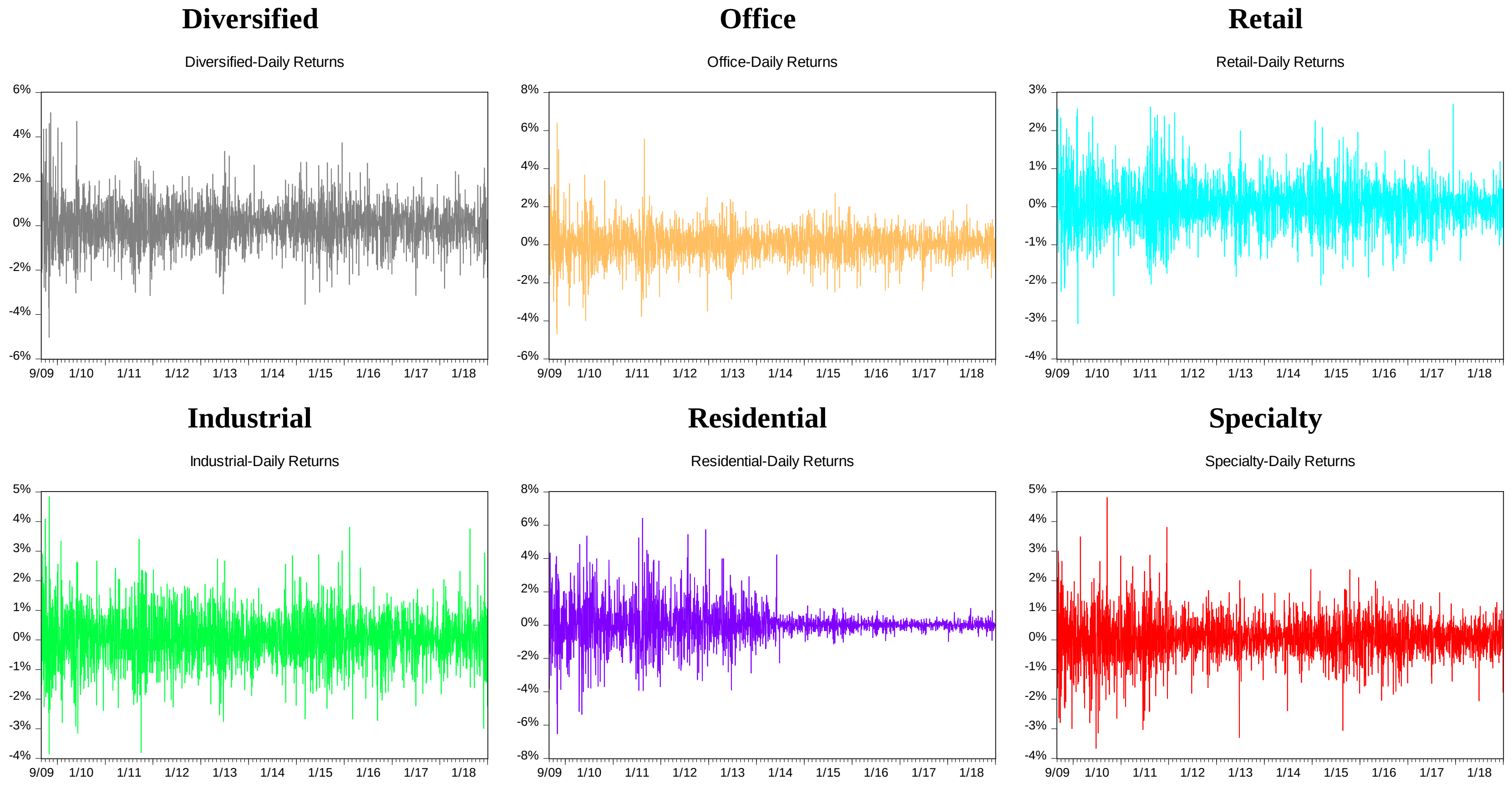


Table 8-9 articulates the coefficients for the main GARCH model over two sub-period timeframes (pre-GFC and post-GFC), using the 3-month and 10-year interest rate series. Prior to the GFC, the coefficients of the parameter θ_j for the half of the A-REIT sub-sectors (namely, office, retail and industrial) in the mean equation were positive and significant. This means excess returns for these sector-specific A-REITs were affected by the corresponding volatility, consistent with the mainstream financial economy and property literature, as the risk-return features of financial time series. The parameter θ_j was insignificant for residential, specialty and diversified REITs. This indicates the lack of a risk-return trade-off for these A-REIT sub-sectors and disproves the null hypothesis of $\theta_j = 0$ (H_1). An interesting finding are that the addition of market excess returns presented as insignificant in the mean equation for most A-REIT sub-sectors in the pre-GFC context. The only exception was residential REITs, which were positively affected by movements in excess returns of the market equity. Changes in the volatility of the market equity were insignificant to excess returns for most of A-REIT sub-sectors. Industrial REITs was the only exception, positively influenced by fluctuations in market equity volatility. These findings generally reject the null hypothesis of $v_{1j} = 0$ (H_6), indicating market equity was a significant factor in excess returns for A-REIT sub-sectors.

The main findings regarding the interest rate sensitivity of A-REIT sub-sectors indicate that increases in both 3-month and 10-year interest rate levels were related to lower excess returns for office, industrial and diversified REITs. Meanwhile, excess returns of retail REITs were negatively affected by changes in 3-month interest rates, while specialty REITs was negatively influenced by fluctuations in 10-year interest rates. The results for these five REIT sub-sectors were in line with the property literature reporting an inverse relationship between REIT returns and interest rate movements. However, residential REITs was an exception, unaffected by changes in either 3-month or 10-year interest rate levels. Compared with the mean equation, the results offer weaker evidence for the variance equation in the Australian context over the pre-GFC timeframe. Increases in the volatility of both 3-month and 10-year interest rate were associated with lower excess returns for industrial REITs prior to the GFC. The results are consistent with the findings of Devaney (2001) and Lee *et al*. (2014). Lee *et al*. (2014) argue that the inverse relationship between excess returns and the conditional variance of interest rates can be explained by the risk management practices utilised. On the other hand, the other sector-specific and diversified REITs were immune to changes in the conditional variance of both the 3-month and 10-year interest rate series.

Post to the GFC, the results show no significant sign of the trade-off between excess returns and the volatility for all A-REIT sub-sectors. This implies the lack of a risk-return trade-off for all A-REIT sub-sectors in the post-GFC context. A significantly positive influence of the market equity excess returns on excess returns of all A-REIT sub-sectors was found after the GFC. At the same time, excess returns for industrial and residential REITs were found to be affected by changes in the conditional variance of the market equity index. This indicates that the overall equity market had a significant impact on excess returns for all A-REIT sub-sectors in the post-GFC context, disproving the null hypothesis of $v_{1j} = 0$ (H_6). An interesting finding is that time-varying impacts of the level and volatility of the market equity are observed in excess returns for A-REIT sub-sectors. The post-GFC A-REIT sub-sectors were highly affected by excess returns and the volatility of the market equity compared with the GFC levels.

In terms of the interest rate sensitivity of A-REIT sub-sectors, the results present stronger evidence for the variance equation compared with the mean equation in the post-GFC investment context. Specifically, there was no evidence of the influence of changes in either 3-month or 10-year interest rate levels on excess returns for any A-REIT sub-sector. Nevertheless, fluctuations in the 3-month interest rate volatility, as conducted by the parameter v_{2j} in the variance equation, were associated with higher excess returns for diversified REITs. Changes in the 10-year interest rate volatility were related to higher excess returns of residential REITs. However, office, retail, industrial and specialty REITs were immune to changes in the level and volatility of both the 3-month and 10-year interest rate series in the post-GFC context. The long memory of all A-REIT sub-sectors was evidenced by the parameter β_j for all REIT sub-sectors being considerably larger than the value of α_j.

In summary, strong effects of changes in the volatility of interest rates on A-REIT sub-sector excess returns were found in the pre-GFC context, while weaker evidence for both the mean and variance equations was documented in the post-GFC context. Despite the fact that most A-REIT sub-sectors were susceptible to changes in the interest rate level and volatility in the pre-GFC context, diversified and residential REITs were the only A-REIT sub-sectors vulnerable to fluctuations in the interest rate volatility in the post-GFC context. This shows that most sector-specific A-REITs were less sensitive to changes in the 3-month and 10-year interest rate risk than diversified REITs in the post-GFC investment context.

Table 8-9: Sub-period GARCH-M model for Australian sector-specific REITs

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel A: Diversified				
Mean equation				
Const	16.897(1.988)**	4.688(3.593)***	0.062(1.254)	0.051(1.210)
Garch term	0.050(1.064)	0.055(1.505)	−0.023(−0.318)	0.001(0.015)
Market	0.091(0.824)	0.090(0.844)	0.666(40.186)***	0.666(40.106)***
IR	−2.723(−2.041)**	−2.081(−3.945)***	−0.009(−0.655)	−0.026(−1.416)
Variance equation				
Const	0.082(1.583)	0.092(1.659)*	0.009(2.890)***	0.009(2.901)***
Arch	0.151(3.371)***	0.204(3.830)	0.024(3.675)***	0.024(3.676)***
Garch	0.840(18.168)***	0.793(16.381)***	0.960(101.669)***	0.960(100.838)***
Market Vol	0.117(0.307)	−0.021(−0.065)	0.004(0.128)	−0.002(−0.085)
IR Vol	−6.590(−1.426)	−16.195(−0.442)	0.512(1.666)*	2.992(0.195)
Panel B: Office				
Mean equation				
Const	11.314(1.758)*	3.072(2.012)**	0.044(1.251)	0.053(1.761)*
Garch term	0.325(1.476)	0.570(2.085)**	−0.035(−0.520)	−0.031(−0.425)
Market	−0.011(−0.105)	−0.024(−0.190)	0.493(36.208)***	0.493(36.194)***
IR	−1.865(−1.813)*	−1.469(−2.290)**	0.004(0.306)	0.001(0.069)
Variance equation				
Const	0.122(1.505)	0.107(1.987)**	0.009(3.371)***	0.009(3.356)***
Arch	0.113(2.071)**	0.099(2.855)***	0.042(5.027)***	0.041(4.999)***
Garch	0.870(16.902)***	0.884(27.050)***	0.937(78.948)***	0.938(80.091)***
Market Vol	0.253(1.007)	−0.325(−1.065)	−0.001(−0.053)	−0.003(−0.140)
IR Vol	−5.331(−1.304)	17.869(0.475)	0.500(1.417)	3.042(0.240)

Table 8-10: Sub-period GARCH-M model for Australian sector-specific REITs (Cont1)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel C: Retail				
Mean equation				
Const	10.240(1.959)*	1.778(1.583)	0.028(0.997)	0.033(1.385)
Garch term	0.225(1.853)*	0.193(1.745)*	−0.155(−1.433)	−0.158(−1.309)
Market	−0.070(−0.738)	−0.024(−0.300)	0.398(38.038)***	0.397(38.018)***
IR	−1.687(−2.030)**	−0.876(−1.961)**	0.004(0.468)	−0.003(−0.268)
Variance equation				
Const	0.097(1.501)	0.122(1.422)	0.002(2.470)**	0.002(2.471)**
Arch	0.109(2.955)***	0.114(2.073)**	0.025(2.928)***	0.025(2.937)***
Garch	0.852(16.473)***	0.833(10.799)***	0.966(122.371)***	0.966(120.745)***
Market Vol	0.101(0.526)	−0.013(−0.073)	0.015(0.830)	0.011(0.596)
IR Vol	−2.738(−0.737)	6.434(0.230)	0.163(0.459)	10.121(1.006)
Panel D: Industrial				
Mean equation				
Const	15.581(2.382)**	3.378(2.245)**	0.046(0.970)	0.056(1.392)
Garch term	0.266(1.665)*	0.281(1.687)*	0.030(0.312)	0.091(0.990)
Market	0.009(0.093)	0.015(0.155)	0.527(36.373)***	0.522(34.377)***
IR	−2.527(−2.443)***	−1.512(−2.481)**	0.004(0.367)	−0.012(−0.896)
Variance equation				
Const	0.106(1.490)	0.129(1.612)	0.005(3.189)***	0.003(1.881)*
Arch	0.215(3.408)***	0.213(3.317)***	0.015(4.123)***	0.017(3.720)***
Garch	0.778(12.931)***	0.770(12.038)***	0.976(169.067)***	0.976(130.271)***
Market Vol	0.480(1.837)*	0.200(0.748)	−0.041(−2.016)**	−0.033(−1.589)
IR Vol	−13.586(−1.891)*	−63.525(−1.795)**	−0.195(−0.525)	−16.101(−1.379)

Table 8-11: Sub-period GARCH-M model for Australian sector-specific REITs (Cont2)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel E: Residential				
Mean equation				
Const	6.562(0.913)	3.790(2.355)**	0.022(0.782)	0.000(0.003)
Garch term	−0.283(−0.792)	−0.142 (−0.463)	0.047(2.079)**	0.025(1.080)
Market	0.284(2.211)**	0.271(2.153)**	0.042(5.642)***	0.042(5.601)***
IR	−1.062(−0.905)	−1.685(−2.521)**	−0.004(−0.265)	0.004(0.179)
Variance equation				
Const	0.188(1.266)	0.173(1.213)	0.000(2.100)**	0.000(2.064)**
Arch	0.084(2.110)**	0.075(2.063)**	0.029(5.097)***	0.029(5.096)***
Garch	0.892(16.453)***	0.902(17.159)***	0.970(186.734)***	0.970(187.365)***
Market Vol	0.417(1.575)	0.319(1.194)	−0.006(−0.448)	−0.015(−1.032)
IR Vol	−1.110(−0.249)	−0.782(−0.019)	−0.195(−0.361)	17.158(1.785)*
Panel F: Specialty				
Mean equation				
Const	5.786(1.425)	1.840(1.879)*	0.054(1.878)*	0.058(2.398)**
Garch term	0.062(0.909)	0.082(1.146)	−0.075(−1.095)	0.024(0.316)
Market	0.115(1.520)	0.113(1.496)	0.178(13.449)***	0.177(13.386)***
IR	−0.950(−1.475)	−0.845(−2.145)**	0.011(0.787)	−0.026(−1.327)
Variance equation				
Const	0.253(1.806)*	0.231(1.886)*	0.002(2.521)**	0.002(2.539)**
Arch	0.224(2.233)**	0.227(2.310)**	0.015(3.288)***	0.016(3.313)***
Garch	0.694(6.513)***	0.699(7.216)***	0.980(200.122)***	0.980(193.213)***
Market Vol	0.010(0.077)	−0.101(−0.874)	0.011(0.518)	−0.001(−0.034)
IR Vol	−1.493(−0.608)	−2.175(−0.096)	0.185(0.399)	10.448(1.024)

8.4 INTEREST RATE SENSITIVITY OF SECTOR-SPECIFIC REITs IN SINGAPORE

8.4.1 GARCH-M Specification

Table 8-13 documents the descriptive statistics of excess returns for Singapore sector-specific and diversified REITs from 19 July 2006 to 31 December 2018, as well as the measure for the skewness, kurtosis and Jarque-Bera normality test applied on the excess return series. The daily risk-return rankings are generally in line with the monthly risk-return outcomes in Chapter 5. Positive skewness is exhibited for retail, industrial, specialty and diversified REITs, while negative skewness is reported for office and residential REITs. All S-REIT sub-sector distributions display excess kurtosis, and disprove the null hypothesis of a normal distribution conducted by the Jarque-Bera test. The dynamics of 3-month and 10-year interest rates are depicted in **Figure 8-11**. The plots of daily excess returns for each S-REIT sub-sectors are exhibited in **Figure 8-12**. A higher level of volatility was seen for each S-REITs sub-sector during 2007–2009, suggesting that the GFC period was the more volatile timeframe for all S-REIT sub-sector series. Excess returns featured time-varying characteristics with volatility clustering evidence during the sample period, implying the fitness of the GARCH approach to measure six S-REIT sub-sector excess return series.

The suitability of the GARCH framework for six S-REIT sub-sector series is evident from **Figure 8-13**, which depicts the ACF of both excess returns and the volatility for all S-REIT sub-sector series, with the ACF displayed over 36 lags. The results show that lower persistence in excess returns compared with relatively strong persistence in the volatility series, which is consistent with the volatility clustering features of financial time series, particularly in response to the daily REIT data used. Based on the findings of Cotter and Stevenson (2007) and Stevenson *et al*. (2007), the results validate the strong serial correlation of volatility. This indicates the existence of the ARCH effects for daily REIT excess returns, and explains the applicability of GARCH-related processes to daily REIT series. This is confirmed by the LM tests, as presented in **Table 8-13**.

Table 8-12 shows the stationarity test results for six S-REIT sub-sector series and the market equity index, as well as the 3-month (IR 3m) and 10-year interest rate series (IR

10y), with the respective volatilities for market equity index, 3-month and 10-year interest rates from 19 July 2006 to 31 December 2018. The ADF test results of the unit root test at the level disprove the null hypothesis of unit root presence in the time-series with a 1% significance level for most of the variables. The only exceptions are the 3-month and 10-year interest rate series. However, when the time series for all variables were stated in first differences, both the 3-month and 10-year interest rate series disproved the null hypothesis with a 1% significance level. In general, all series are appropriate for further analysis of time-varying return and volatility transmissions.

Table 8-12: ADF unit test for Singapore sector-specific REITs: July 2006–December 2018

	Level		First differences		
Variable	*t*-statistics	*p*-value	*t*-statistics	*p*-value	Stationary
Diversified	−55.464	0.000	−25.784	0.000	*I*(0)
Office	−38.145	0.000	−25.875	0.000	*I*(0)
Retail	−68.034	0.000	−21.840	0.000	*I*(0)
Industrial	−11.732	0.000	−18.916	0.000	*I*(0)
Residential	−53.650	0.000	−22.465	0.000	*I*(0)
Specialty	−56.722	0.000	−25.081	0.000	*I*(0)
Market	−54.823	0.000	−21.796	0.000	*I*(0)
IR 3m	−2.034	0.582	−21.130	0.000	*I*(1)
IR 10y	−1.987	0.608	−23.639	0.000	*I*(1)
Market Vol.	−4.718	0.000	−15.789	0.000	*I*(0)
IR 3m Vol.	−7.428	0.000	−18.737	0.000	*I*(0)
IR 10y Vol.	−8.911	0.000	−89.528	0.000	*I*(0)

Note: H_0-non-stationary

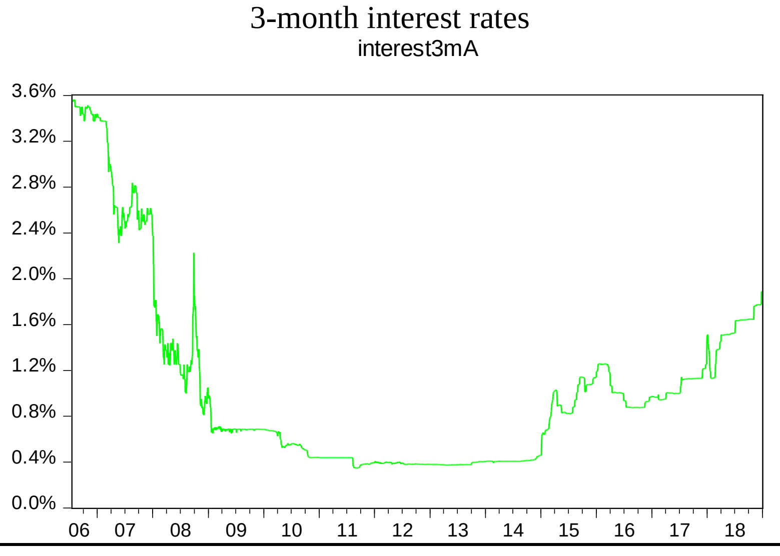
Table 8-14 shows the coefficients for the main GARCH model, using the 3-month and 10-year interest rate series. Hypothesis 1 ($\theta_j = 0$) examines whether the volatility is a significant factor in excess returns of S-REIT sub-sectors. The coefficients of the GARCH term, the trade-off between excess returns and its volatility, were found to be insignificant for all S-REIT sub-sectors over the entire study period. Based on the findings of Baillie and DeGennaro (1990), Elyasiani and Mansur (1998), Stevenson *et al*. (2007) and Lee *et al*. (2014), the results imply the lack of a risk-return trade-off for all S-REIT sub-sectors over the full study period. The differences in magnitude across six S-REIT sub-sector series were also witnessed over the entire study timeframe. This can be elucidated by the influence of the GFC, movements towards privatisation, market-oriented policies and the market maturity of varying individual market involvements, as noted by Choudhry (1996).

Table 8-13: Summary statistics for Singapore sector-specific REITs: July 2006–December 2018

	Diversified	**Office**	**Retail**	**Industrial**	**Residential**	**Specialty**
Mean(%)	0.048	0.029	0.041	0.040	0.035	0.058
Median(%)	0.028	0.035	0.031	0.031	0.023	0.027
Maximum(%)	13.741	10.603	51.881	11.473	9.780	9.044
Minimum(%)	−12.113	−13.862	−32.657	−11.229	−13.660	−9.790
Standard deviation(%)	1.497	1.362	1.605	1.298	1.340	1.254
Skewness	0.355	−0.097	7.917	0.200	−0.039	0.221
Kurtosis	13.464	17.976	392.811	15.335	12.800	11.907
Jarque-Bera	14,889.90***	30,366.69***	20,604,499***	20,619.78***	13,003.34***	10,765.24***
LM test	240.588***	69.567***	131.635***	100.086***	44.400***	145.489***

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

Figure 8-11: 3-month and 10-year interest rates in Singapore: July 2006–December 2018



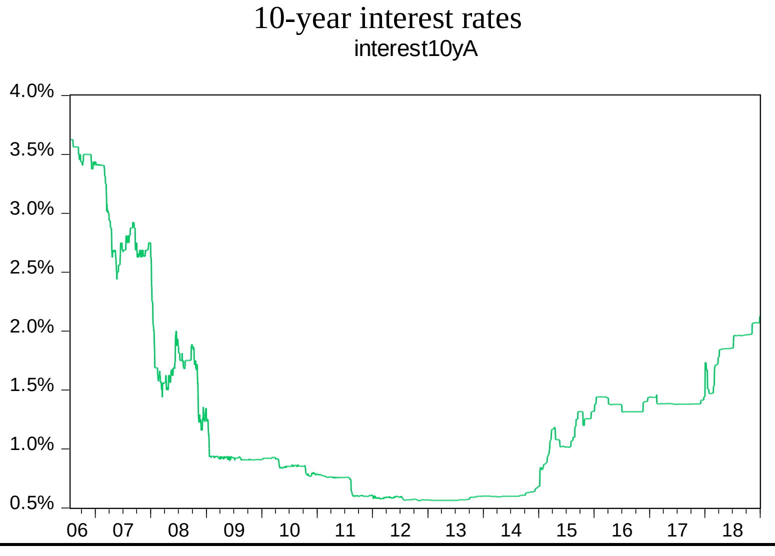


Figure 8-12: Excess returns for Singapore sector-specific REITs: July 2006–December 2018

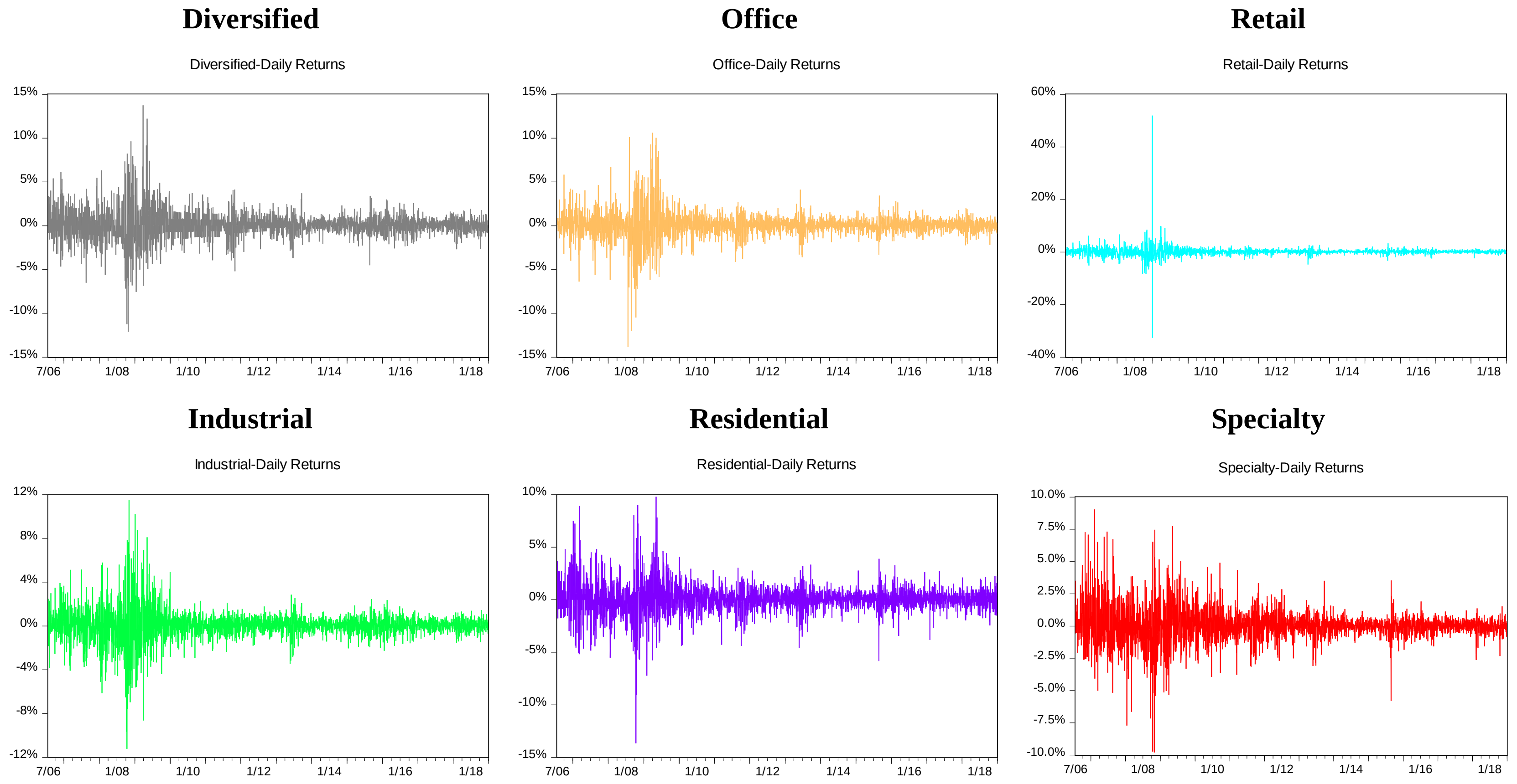
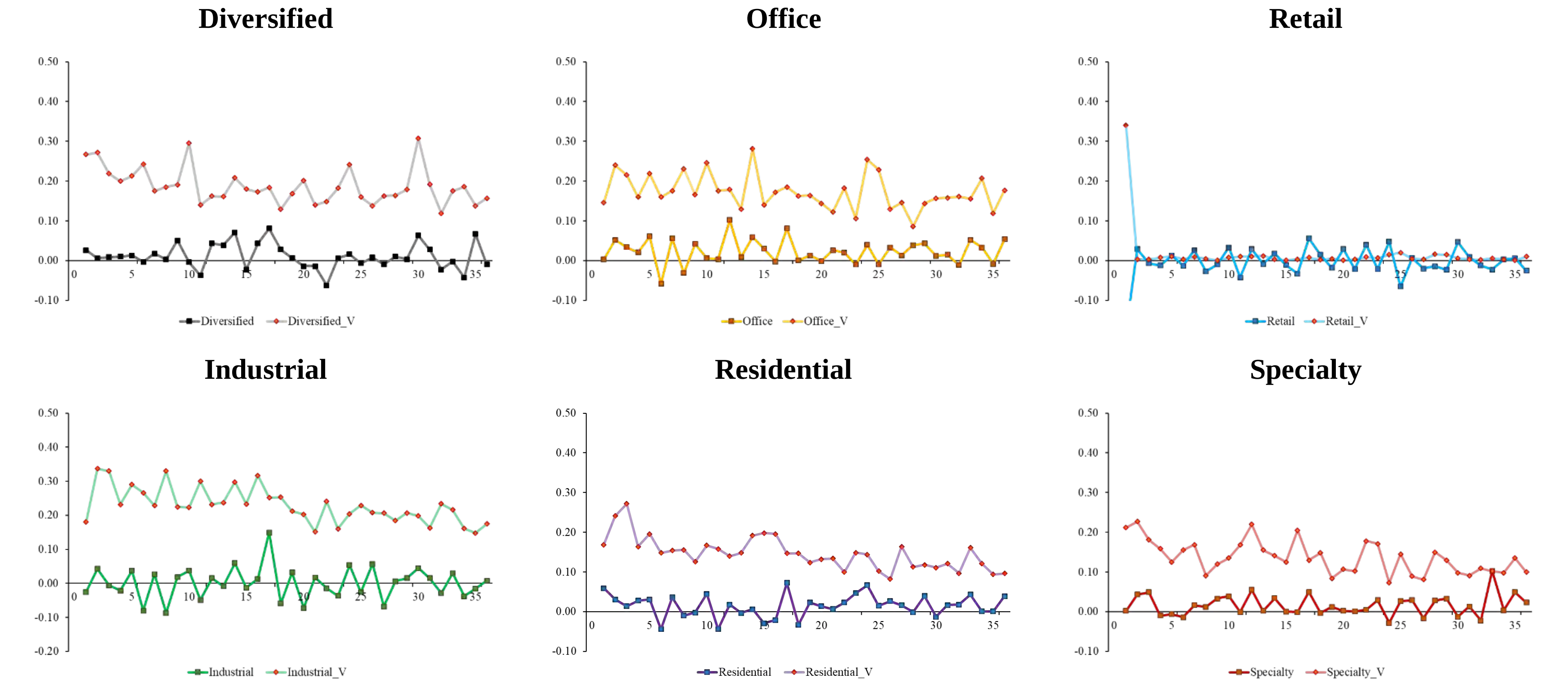


Figure 8-13: Autocorrelation plots for excess returns and volatility of Singapore sector-specific REITs: July 2006–December 2018



To investigate the presence of ARCH and GARCH effects, hypothesis 2 ($\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$) was tested. The results disprove the null hypothesis and show that the volatility of excess returns was time-variant. To measure whether the return-generating process serves ARCH, ARCH-M and GARCH specifications, hypotheses 3 ($\theta_j = \beta_j = v_{1j} = v_{2j} = 0$), 4 ($\beta_j = v_{1j} = v_{2j} = 0$) and 5 ($\theta_j = v_{1j} = v_{2j} = 0$) were tested respectively. The results disprove the null hypotheses; however, these findings contradict the initial finding that the volatility was not a significant factor in excess returns. Hypothesis 6 ($v_{1j} = 0$) tests whether the market equity is a significant factor in excess returns of S-REIT sub-sectors. Increases in excess returns of the market equity were associated with higher excess returns for all S-REIT sub-sectors. The conditional variance of excess market returns was only significant in the variance equations for retail REITs, rather than the other sector-specific and diversified REITs. The results show that retail REITs was more susceptible to changes in excess returns and the volatility of the market equity compared with the other sector-specific and diversified REITs over the full sample period. Since the parameter β_j was considerably larger than the values of α_j for all S-REIT sub-sectors, there was some evidence for the long memory of S-REIT sub-sectors.

Generally, the findings concerning the interest rate sensitivity of all S-REIT sub-sectors offer weaker evidence for the mean equation compared with the variance equation. Specifically, no significant μ_j was found for excess returns of either sector-specific and diversified REITs affected by changes in either the 3-month or 10-year interest rate series. In the variance equation, increases in the 3-month interest rate volatility, as undertaken by the parameter v_{2j}, were associated with lower excess returns of diversified REITs. In other words, the significance of excess returns of diversified REITs in relation to changes in 3-month interest rate volatility was at a 5% significance level. All property types of S-REITs were immune to fluctuations in the volatility of both the 3-month and 10-year interest rate series over the full study period. In brief, all property types of S-REITs were seen to be less sensitive to the short- and longer-term interest rate risk compared with diversified REITs in the Singapore context over the entire study period.

Table 8-14: GARCH-M model for Singapore sector-specific REITs: July 2006–December 2018

	Diversified		**Office**		**Retail**	
	3M	10Y	3M	10Y	3M	10Y
Mean equation						
Const	0.034(1.435)	0.045(1.645)*	0.053(2.591)***	0.059(2.540)***	−0.006(−0.331)	−0.011(−0.487)
Garch term	0.003(0.152)	0.002(0.111)	−0.032(−1.217)	−0.032(−1.247)	−0.002(−0.097)	−0.003(−0.142)
Market	0.681(42.645)***	0.679(42.436)***	0.617(45.615)***	0.617(45.718)***	0.546(45.985)***	0.545(46.237)***
IR	−0.001(−0.027)	−0.008(−0.344)	−0.013(−0.687)	−0.015(−0.782)	−0.033(−1.735)	−0.017(−0.884)
Variance equation						
Const	0.004(2.434)**	0.004(2.451)**	0.004(3.336)***	0.004(3.338)***	−0.000(−0.584)	−0.000(−0.639)
Arch	0.048(7.114)***	0.048(7.124)***	0.039(6.560)***	0.039(6.565)***	0.035(12.350)***	0.045(12.595)***
Garch	0.950(146.471)***	0.949(144.766)***	0.955(156.254)***	0.955(155.998)***	0.954(260.262)***	0.954(264.789)***
Market Vol	−0.001(−0.026)	−0.010(−0.417)	0.012(0.575)	0.009(0.426)	0.130(6.115)***	0.134(6.633)***
IR Vol	−36.899(−2.083)**	−36.334(−1.563)	−11.797(−0.785)	−10.390(−0.526)	12.156(0.861)	−25.005(−1.409)
	Industrial		**Residential**		**Specialty**	
Mean equation						
Const	0.020(1.149)	0.024(1.176)	0.035(1.529)	0.045(1.667)*	0.026(1.334)	0.039(1.698)*
Garch term	−0.022(−0.801)	−0.024(−0.882)	0.004(0.151)	0.003(0.115)	0.013(0.560)	0.010(0.459)
Market	0.533(41.695)***	0.533(42.002)***	0.535(34.377)***	0.537(34.580)***	0.452(34.940)***	0.451(34.912)***
IR	0.006(0.347)	0.001(0.041)	−0.022(−0.925)	−0.022(−0.914)	−0.001(−0.067)	−0.013(−0.694)
Variance equation						
Const	0.002(3.891)***	0.002(3.882)***	0.006(3.206)***	0.006(3.196)***	0.001(2.738)***	0.001(2.743)***
Arch	0.053(10.608)***	0.053(10.619)***	0.021(4.334)***	0.021(4.329)***	0.033(4.771)***	0.033(4.772)***
Garch	0.945(206.861)***	0.945(206.677)***	0.945(117.171)***	0.945(117.997)	0.966(189.104)***	0.966(188.383)***
Market Vol	0.023(1.034)	0.022(1.016)	0.020(0.871)	0.016(0.702)	−0.001(−0.034)	−0.005(−0.276)
IR Vol	−7.667(−0.562)	−0.763(−0.042)	−25.548(−1.462)	−34.840(−1.379)	−12.391(−0.781)	10.235(0.508)

8.4.2 Sub-period Analysis

Table 8-16 articulates the summary statistics for daily excess returns of all S-REIT sub-sectors, as well as the statistics testing for normality over two sub-periods: the pre-GFC and post-GFC timeframes. Prior to the GFC, positive skewness is documented for retail, industrial, residential, specialty and diversified REITs, while negative skewness is only presented for office REITs. Excess kurtosis is documented for all S-REIT sub-sector distributions, disproving the null hypothesis of normal distribution based on the Jarque-Bera statistics. Post to the GFC, negative skewness and excess kurtosis are presented for all S-REIT sub-sectors, disproving the null hypothesis of normal distribution based on the Jarque-Bera statistics. The plots of daily excess returns for each S-REIT sub-sector over two sub-periods are displayed in **Figure 8-14** and **Figure 8-15**, respectively. The suitability of the GARCH framework for each S-REIT sub-sector series is reinforced by **Figure 8-13**, demonstrating the ACF test on both excess returns and the volatility for all S-REIT sub-sector series, with the ACF displayed over 36 lags.

Table 8-17 reports the ADF test on the level and first differences for daily excess returns of six S-REIT sub-sector series and the market equity index, as well as the 3-month (IR 3m) and 10-year interest rate series (IR 10y) over the pre-GFC (Panel A) and post-GFC timeframes (Panel B), with the respective volatilities for market equity index and 3-month and 10-year interest rates. Prior to the GFC, t-statistic values for both the 10-year interest rate series and volatility of the market equity index did not exhibit the statistical significance required to reject the null hypothesis of the unit root. Post-GFC, neither the 3-month nor the 10-year interest rate series disproved the null hypothesis of the unit root. All series were then transformed by taking first differences, and all variables in the pre-GFC and post-GFC investment contexts strongly rejected the null hypothesis at a 1% significance level. These series are appropriate for further analysis of time-varying return and volatility transmissions over two sub-periods.

Table 8-16: Sub-period summary statistics for Singapore sector-specific REITs

	Diversified		Office		Retail	
	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC
Mean(%)	0.177	0.052	0.132	0.041	0.155	0.041
Median(%)	0.018	0.030	0.115	0.044	0.087	0.038
Minimum(%)	6.156	4.895	5.829	4.102	6.179	3.207
Maximum(%)	−6.504	−5.212	−6.372	−4.137	−5.156	−4.792
Standard deviation(%)	1.796	0.974	1.446	0.808	1.471	0.723
Skewness	0.057	−0.077	−0.171	−0.295	0.134	−0.400
Kurtosis	3.849	5.821	5.975	5.606	4.922	6.103
Jarque-Bera	8.78**	809.89***	107.21***	724.26***	45.021**	1,041.55***
	Industrial		**Residential**		**Specialty**	
Mean(%)	0.122	0.043	0.187	0.035	0.338	0.040
Median(%)	0.019	0.035	0.010	0.024	0.000	0.033
Minimum(%)	5.146	4.923	8.909	4.052	9.044	4.925
Maximum(%)	−4.084	−4.399	−5.188	−5.861	−5.164	−5.776
Standard deviation(%)	1.471	0.708	2.026	0.900	2.153	0.799
Skewness	0.065	−0.098	0.507	−0.422	0.900	−0.049
Kurtosis	4.073	6.856	4.984	6.341	4.651	8.412
Jarque-Bera	13.97***	1,512.22***	59.38***	1,204.96***	71.35***	2,973.07***

Figure 8-14: Excess returns for Singapore sector-specific REITs: pre-GFC: July 2006–September 2007

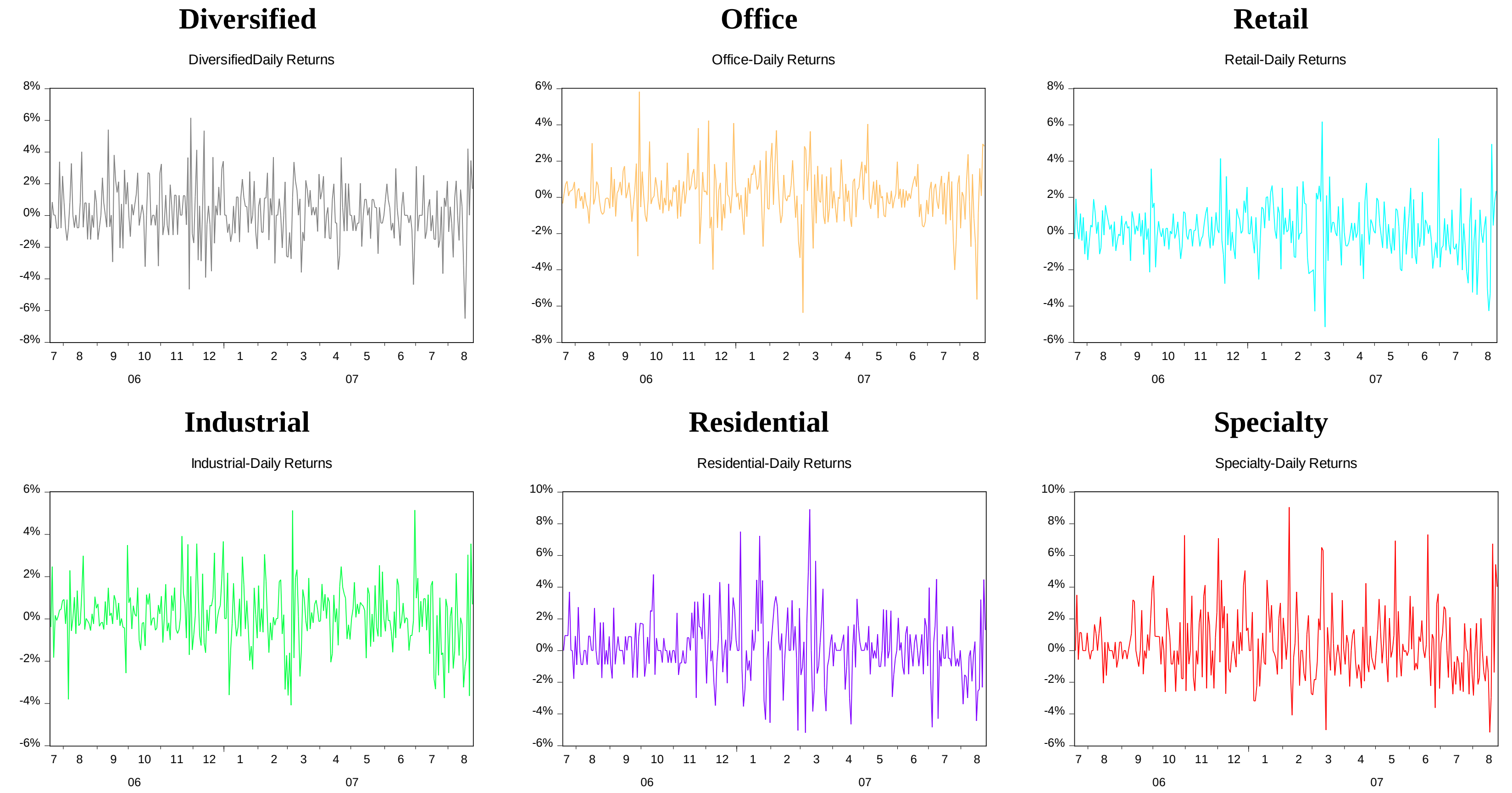


Figure 8-15: Excess returns for Singapore sector-specific REITs: post-GFC: July 2009–December 2018

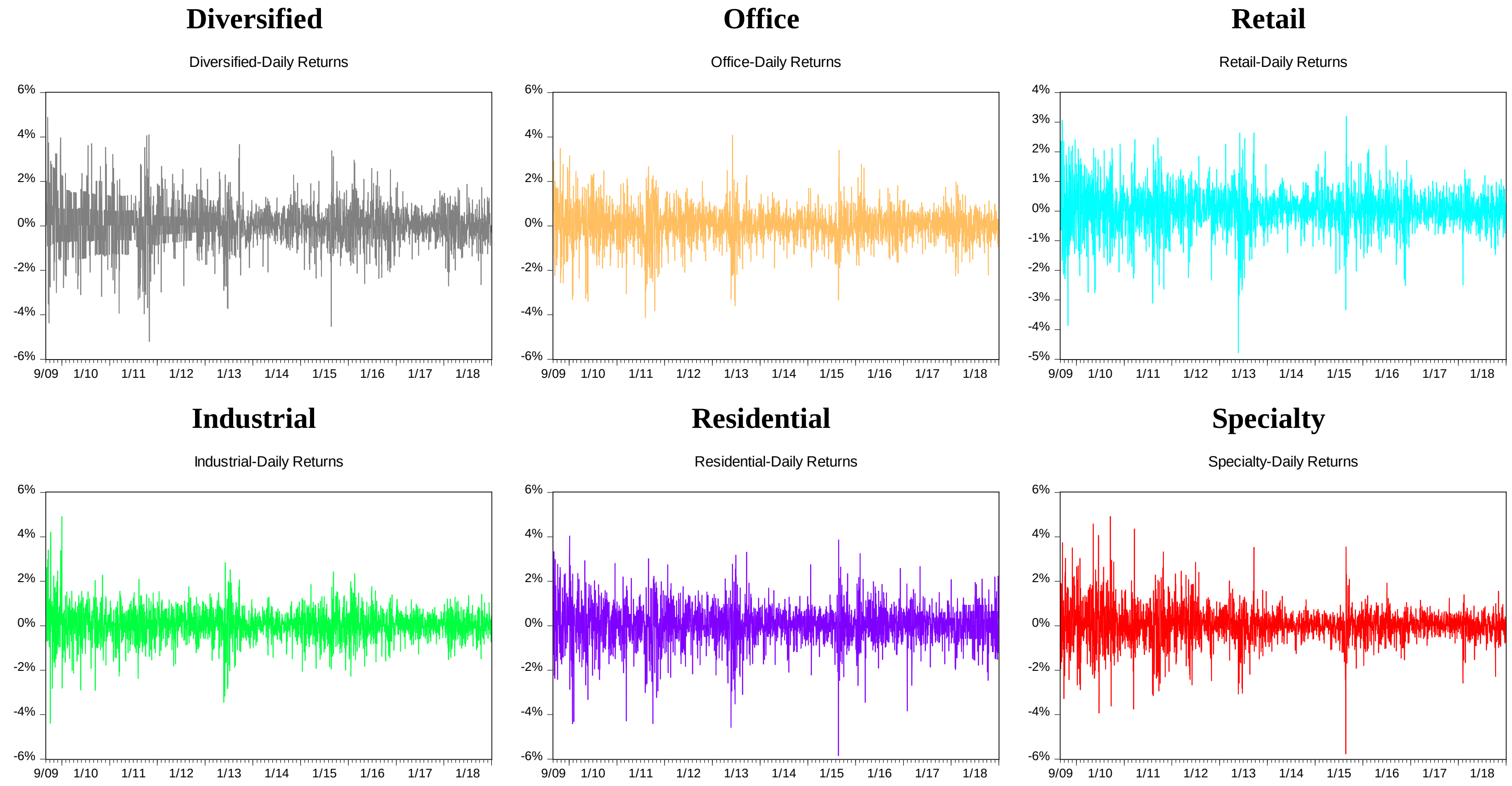


Table 8-17: Sub-period ADF unit test for Singapore sector-specific REITs

Variable	Level		First differences		Stationary
	t-statistics	*p*-value	*t*-statistics	*p*-value	
Panel A: Pre-GFC: July 2006–September 2007					
Diversified	−18.520	0.000	−13.317	0.000	*I*(0)
Office	−16.118	0.000	−16.777	0.000	*I*(0)
Retail	−16.312	0.000	−10.491	0.000	*I*(0)
Industrial	−17.796	0.000	−10.560	0.000	*I*(0)
Residential	−15.760	0.000	−10.379	0.000	*I*(0)
Specialty	−15.693	0.000	−16.445	0.000	*I*(0)
Market	−16.938	0.000	−10.562	0.000	*I*(0)
IR 3m	−1.760	0.075	−14.528	0.000	*I*(0)
IR 10y	−1.667	0.090	−9.096	0.000	*I*(1)
Market Vol.	0.991	0.915	−11.394	0.000	*I*(1)
IR 3m Vol.	−9.720	0.000	−56.024	0.000	*I*(0)
IR 10y Vol.	−14.411	0.000	−65.354	0.000	*I*(0)
Panel B: Post-GFC: July 2009−December 2018					
Diversified	−48.710	0.000	−23.566	0.000	*I*(0)
Office	−32.695	0.000	−23.022	0.000	*I*(0)
Retail	−49.398	0.000	−21.598	0.000	*I*(0)
Industrial	−49.737	0.000	−21.522	0.000	*I*(0)
Residential	−49.398	0.000	−21.598	0.000	*I*(0)
Specialty	−50.446	0.000	−20.701	0.000	*I*(0)
Market	−47.770	0.000	−23.374	0.000	*I*(0)
IR 3m	2.653	0.998	−40.016	0.000	*I*(1)
IR 10y	2.692	0.999	−40.682	0.000	*I*(1)
Market Vol.	−5.384	0.000	−50.140	0.000	*I*(0)
IR 3m Vol.	−7.299	0.000	−48.622	0.000	*I*(0)
IR 10y Vol.	−7.925	0.000	−14.854	0.000	*I*(0)

Note: H_0-non-stationary

Table 8- details the coefficients for the main GARCH model for all S-REIT sub-sectors over two sub-periods, using the 3-month and 10-year interest rate series. Prior to the GFC, the parameter θ_j for all S-REIT sub-sectors was found to be insignificant. This indicates the lack of a risk-return trade-off for all S-REIT sub-sectors in the pre-GFC investment context, which is consistent with the findings of Elyasiani and Mansur (1998). The results disprove the null hypothesis of $\theta_j = 0$ (H_1). Increases in excess returns of the market equity index were reported to be related to higher excess returns for all S-REIT sub-sectors. Changes in the volatility of excess returns of the market equity were found to positively affect excess returns only of specialty REITs, not of the other sector-specific and diversified REITs. The results offer strong evidence for rejecting the null hypothesis

of $v_{1j} = 0$ (H_6). This implies that the overall equity market had a significant influence on excess returns for all S-REIT sub-sectors.

The findings of the interest rate sensitivity of all S-REIT sub-sectors provide stronger evidence of the mean equation than the variance equation. Specifically, most sector-specific and diversified REIT excess returns were unaffected by changes in the level of either the 3-month or the 10-year interest rate series. Nonetheless, increases in both 3-month and 10-year interest rate levels were associated with higher excess returns of retail REITs in the pre-GFC context. The positive μ_j for retail REITs runs counter to the mainstream financial economy and property literature's assertions concerning debt costs, yields and the general economic impact of interest rates on demand in the property sector (Bredin *et al.*, 2011). However, Stevenson *et al*. (2007) and Lee *et al*. (2014) document the positive significance of the sensitivity of listed property markets in the USA, the UK, Germany and the Netherlands to interest rate changes during the period of lower interest rate volatility in these four markets. Besides, the low interest rate investment environment in Singapore may illustrate the positive sign of retail REITs at a 10% significance level. In the variance equation, no evidence was presented for the 3-month and 10-year interest rate sensitivity of any S-REIT sub-sector in the pre-GFC investment context.

Post to the GFC, the trade-off between excess returns and volatility reflected by the parameter θ_j for retail and industrial REITs showed negative and significant signs. As noted by Elyasiani and Mansur (1998) and Glosten *et al*. (1993), the negative direction of the coefficient on the GARCH terms for retail and industrial REITs can be clarified by these two sector-specific REITs being less affected by random shocks than other assets in the marketplace. As such, investors switched their investment to retail and industrial REITs, and the substitution process resulted in a lower premium and a higher price level for these two sector-specific REITs. This is backed by the lower correlations with stocks for retail ($r = 0.66$) and industrial REITs ($r = 0.60$) than for the other S-REIT sub-sectors (average $r = 0.69$), as documented in Chapter 5. On the other hand, office, residential, specialty and diversified REITs were short of a risk-return trade-off, evident from the insignificant parameter θ_j for these three S-REIT sub-sectors. These findings disprove the null hypothesis of $\theta_j = 0$ (H_1). In terms of the impact of the market equity on excess returns of S-REIT sub-sectors, increases in excess returns of market equity were associated with higher excess returns for all S-REIT sub-sectors in the post-GFC context. In addition, increases in the volatility of the market equity, as measured by the conditional variance of the market equity in the variance equation, were related to higher excess returns for industrial REITs than for the other sector-specific and diversified REITs. These findings disprove the null hypothesis of $v_{1j} = 0$ (H_6). For the interest rate sensitivity of S-REIT sub-sectors, the results offer no evidence for the impact of changes in either 3-month or 10-year interest rates levels and the volatility on excess returns for any S-REIT sub-sectors. The long memory of all S-REIT sub-sectors was evident from the parameter β_j being larger than the values of α_j over the two sub-periods.

In brief, retail REITs was the only S-REIT sub-sector affected by fluctuations in the level and volatility of either the 3-month or the 10-year interest rate series in the pre-GFC context. Apart from retail REITs, all property types of S-REITs and diversified S-REITs were immune to changes in the interest rate level and volatility over both sub-periods. In terms of the influence of the market equity, all property type of S-REITs were highly influenced by movements in excess returns of the market equity over two sub-periods. Industrial REITs was affected by changes in the volatility of the market equity post to the GFC, as were specialty REITs in the pre-GFC context. Singapore retail and industrial REITs were less affected by random shocks than the other assets in the marketplace in the post-GFC context, as is evident from the negative direction of the parameter θ_j.

Table 8-18: Sub-period GARCH-M model for Singapore sector-specific REITs

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel A: Diversified				
Mean equation				
Const	−0.961(−0.942)	−1.060(−0.965)	0.067(1.591)	0.075(1.639)
Garch term	0.078(0.245)	0.066(0.210)	−0.033(−0.647)	−0.031(−0.627)
Market	0.786(9.473)***	0.788(9.592)***	0.627(33.783)***	0.626(33.748)***
IR	0.261(1.048)	0.298(1.038)	−0.008(−0.214)	−0.018(−0.536)
Variance equation				
Const	0.404(0.992)	0.409(0.986)	0.008(2.651)***	0.008(2.652)***
Arch	0.042(1.130)	0.042(1.123)	0.054(5.395)***	0.054(5.396)***
Garch	0.791(4.200)***	0.789(4.118)***	0.936(82.622)***	0.936(82.442)***
Market Vol	0.034(0.243)	0.039(0.275)	−0.006(−0.154)	−0.009(−0.232)
IR Vol	−5.999(−0.096)	−16.648(−0.206)	−50.491(−0.976)	−19.686(−0.507)
Panel B: Office				
Mean equation				
Const	−0.103(−0.219)	−0.024(−0.044)	0.053(1.410)	0.055(1.363)
Garch term	−0.008(−0.046)	0.023(0.137)	−0.081(−1.000)	−0.077(−0.969)
Market	0.617(11.424)***	0.614(11.368)***	0.586(38.508)***	0.586(38.490)***
IR	0.013(0.084)	−0.025(−0.143)	−0.012(−0.368)	−0.013(−0.489)
Variance equation				
Const	0.165(1.200)	0.164(1.221)	0.005(3.940)***	0.005(3.939)***
Arch	0.083(1.704)*	0.084(1.708)*	0.041(7.239)***	0.041(7.232)***
Garch	0.807(6.726)***	0.808(6.924)***	0.946(131.864)***	0.946(131.926)***
Market Vol	0.034(0.424)	0.013(0.159)	0.038(1.168)	0.036(1.100)
IR Vol	19.382(0.513)	38.382(0.815)	−42.652(−0.995)	−26.702(−0.803)

Table 8-18: Sub-period GARCH-M model for Singapore sector-specific REITs (Cont1)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel C: Retail				
Mean equation				
Const	−0.781(−1.592)	−0.910(−1.616)	0.064(2.057)**	0.068(1.977)**
Garch term	−0.617(−1.568)	−0.626(−1.563)	−0.156(−1.986)**	−0.154(−1.984)**
Market	0.834(14.759)***	0.834(14.757)***	0.511(40.102)***	0.511(40.142)***
IR	0.253(1.705)*	0.289(1.694)*	−0.016(−0.562)	−0.015(−0.616)
Variance equation				
Const	0.560(1.775)*	0.543(1.704)*	0.004(3.942)***	0.004(3.945)***
Arch	0.150(1.489)	0.144(1.458)	0.046(7.859)***	0.046(7.855)***
Garch	0.383(1.223)	0.401(1.268)	0.941(120.896)***	0.941(120.875)***
Market Vol	0.129(1.481)	0.135(1.533)	0.053(1.926)*	0.053(1.917)*
IR Vol	−41.595(−1.052)	−61.480(−1.171)	−25.232(−0.692)	−26.564(−0.988)
Panel D: Industrial				
Mean equation				
Const	−0.118(−0.202)	−0.086(−0.135)	0.060(2.210)**	0.063(2.096)**
Garch term	0.182(0.351)	0.144(0.288)	−0.144(−2.203)***	−0.144(−2.200)**
Market	0.676(11.473)***	0.677(11.519)***	0.487(35.840)***	0.487(35.811)***
IR	0.027(0.162)	0.028(0.151)	−0.006(−0.247)	−0.008(−0.380)
Variance equation				
Const	0.489(0.805)	0.471(0.804)	0.005(3.198)***	0.005(3.200)***
Arch	0.073(0.901)	0.074(0.918)	0.058(5.783)***	0.058(5.783)***
Garch	0.623(1.469)	0.633(1.536)	0.927(78.777)***	0.926(78.630)***
Market Vol	−0.082(−1.080)	−0.076(−0.995)	0.049(1.995)**	0.048(1.963)**
IR Vol	13.822(0.326)	−2.412(−0.043)	−26.027(−0.844)	−16.122(−0.732)

Table 8-18: Sub-period GARCH-M model for Singapore sector-specific REITs (Cont2)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel E: Residential				
Mean equation				
Const	−0.772(−0.945)	−0.740(−0.787)	0.071(1.886)*	0.074(1.830)*
Garch term	−0.019(−0.248)	−0.020(−0.255)	−0.031(−0.543)	−0.032(−0.563)
Market	0.602(6.615)***	0.608(6.727)***	0.502(27.545)***	0.503(27.566)***
IR	0.251(1.008)	0.238(0.825)	−0.021(−0.652)	−0.018(−0.629)
Variance equation				
Const	0.396(1.968)**	0.400(1.982)**	0.014(3.218)***	0.014(3.213)***
Arch	0.177(3.311)***	0.178(3.326)***	0.056(5.230)***	0.056(5.229)***
Garch	0.722(8.953)***	0.719(8.889)***	0.923(66.779)***	0.923(67.036)***
Market Vol	−0.004(−0.039)	−0.009(−0.092)	−0.011(−0.318)	−0.010(−0.290)
IR Vol	46.650(0.735)	62.996(0.781)	−12.988(−0.277)	−25.206(−0.760)
Panel F: Specialty				
Mean equation				
Const	0.679(0.449)	−0.089(−0.064)	0.054(2.090)**	0.056(1.969)**
Garch term	−0.788(−1.402)	−0.591(−1.336)	−0.023(−0.477)	−0.021(−0.455)
Market	0.835(8.849)***	0.835(8.774)***	0.409(29.054)***	0.409(29.048)***
IR	0.147(0.537)	0.259(0.854)	−0.024(−0.935)	−0.019(−0.883)
Variance equation				
Const	0.140(1.192)	0.125(1.140)	0.004(3.177)***	0.004(3.175)***
Arch	0.029(0.826)	0.029(0.871)	0.059(3.847)***	0.059(3.841)***
Garch	0.950(24.164)***	0.948(22.981)***	0.935(91.169)***	0.936(91.283)***
Market Vol	0.262(2.153)**	0.271(2.246)**	−0.003(−0.098)	−0.004(−0.122)
IR Vol	−124.965(−1.540)	−125.451(−1.518)	21.968(0.721)	15.947(0.697)

8.5 SUMMARY OF FINDINGS

This chapter investigated whether the level and volatility of short- and long-term interest rate series affected excess returns for Asia-Pacific REITs, complementing the body of the investment performance analysis of Asia-Pacific sector-specific REITs detailed in the preceding chapters. Using daily excess returns of six REIT sub-sector indices (office, retail, industrial, residential, specialty and diversified REITs) across various domestic jurisdictions in the Asia-Pacific (Japan, Australia and Singapore) from 19 July 2006 to 31 December 2018, the short- and long-term interest rate sensitivity of Asia-Pacific sector-specific REITs were analysed using the GARCH-M specification framework. The summary results of this chapter are documented in **Table 8-**.

For diversified REITs, the impact of changes in the volatility of 3-month interest rates on excess returns was evident in all three markets over the full study timeframe, as seen in Panel A. In addition, the influence of fluctuations in the level of 10-year interest rates on diversified REIT excess returns can be seen in Japan and Australia. Meanwhile, diversified REIT excess returns were affected by movements in the volatility of 10-year interest rates in Australia. Compared with diversified REITs, specialty REITs was immune to movements in both the level and volatility of 3-month and 10-year interest rate series across these three markets over the entire study period. Office and retail REITs were affected by changes in the volatility of 3-month and 10-year interest rates in Australia. These two sector-specific REIT were insusceptible to changes in short- and long-term interest rates in Japan and Singapore. In the Japan context, industrial REITs was found to be sensitive to fluctuations in the level of both the 3-month and 10-year interest rate series. Residential REITs was vulnerable to changes in the level of 3-month interest rates in Japan and Australia.

Time-varying results have been reported in Panels B and C. Prior to the GFC (Panel B), diversified REITs was vulnerable to changes in the volatility of 3-month interest rates and the level of 10-year interest rates in Japan, as well as movements in the level of both the short- and long-term interest rate series in Australia. However, industrial REITs was documented as being the most susceptible REIT sub-sector to interest rate movements, sensitive to changes in the level and volatility of both 3-month and 10-year interest rates in Australia, as well as the influence of fluctuations in the level of 10-year interest rates in Japan. Retail REITs was comparable with diversified REITs in terms of interest rate sensitivity. Its excess returns were affected by changes in the 3-month interest rate level in Australia and Singapore, as well as movements in the 10-year interest rate level in Japan and Singapore. On the other hand, residential REITs was found to be the least susceptible REIT sub-sector to interest rate changes in the Asia-Pacific context, despite being influenced by changes in the level of 10-year interest rates in Japan. It was followed by specialty and office REITs. These two assets were only affected by changes in the level of 10-year interest rates in Japan and Australia. Office REITs was also influenced by movements in the level of 3-month interest rates in Australia. Another interesting finding is that all REIT sub-sectors were sensitive to changes in the level of 10-year interest rates in Japan. Furthermore, all REIT sub-sector were susceptible to fluctuations in the level of 10-year interest rates in Australia, except for retail and residential REITs.

Post to the GFC (Panel C), all REIT sub-sectors across these three markets were less susceptible to interest rate movements than the pre-GFC levels. Office REITs was immune to interest rate fluctuations. Most REIT sub-sectors were affected by changes in the level of 3-month interest rates in Japan, including retail, industrial, residential and specialty REITs. At the same time, industrial and specialty REITs were sensitive to movement in the level of 10-year interest rates in Japan. Residential REITs was reported to be vulnerable to changes in the 10-year interest rate volatility in Australia, while diversified REITs was susceptible to movements in the 3-month interest rate level. An interesting finding is that all REIT sub-sectors in Singapore were unaffected by interest rate movements.

8.6 SUMMARY OF CHAPTER

Overall, the results of this chapter indicate that diversified REITs in the Asia-Pacific context were more sensitive to fluctuations in the level and volatility of both the short- and long-term interest rates than were sector-specific REITs in the region. This may be attributed to the fact that a diversified REIT portfolio comprises multiple property sectors. The lack of significance of the interest rate level and volatility effects on sector-specific REIT excess returns across various domestic jurisdictions in the Asia-Pacific implies that sector-specific REITs featured stronger interest rate risk aversion and interest rate hedging actions than diversified REITs in the region. The full period results are reinforced by the sub-period outcomes. The differences can be clarified by the coverage of two sub-periods but not the GFC period, which has been seen as the most volatile period in the international property investment space.

Of sector-specific REITs, industrial REITs was the most susceptible REIT sub-sector to changes in the short- and long-term interest rate levels in Japan over the full study period. It was also reported to be the most sensitive REIT sub-sector to interest rate changes in Australia prior to the GFC. However, industrial REITs was reported to be insusceptible to interest rates changes in Australia and Singapore post to the GFC. This may be attributed to the changing trajectory of property portfolio components of industrial REITs, in that I&L REITs have transformed the traditional industrial properties to logistics properties in the post-GFC context in order to gain strategic exposure to recent e-commerce trends, as noted by Lin *et al.* (2020). Residential REITs was sensitive to long-term interest rate changes in Japan and Australia over the entire study period, particularly after the GFC. Furthermore, retail REITs was verified to be affected by interest rate movements in all three markets prior to the GFC. However, office and specialty REITs were the least susceptible to interest rate changes in the Asia-Pacific context over the full study period, including two sub-periods. This may be attributed to the distinct lease structures of each property sector (Crosby *et al*., 2003; Ambrose and Yildirim, 2008; Agarwal *et al.*, 2011). Specifically, the residential property lease is typically short-term, while office, retail and industrial properties are leased on a long-term basis (Miles and McCue, 1982). Retail properties are more volatile than office and industrial properties owing to percentage rent in retail property leasing (Crosby *et al*., 2003).

The disparities in the magnitude and direction of the sensitivity to the level and volatility of interest rates among six REIT sub-sectors and across three REIT markets in the Asia-Pacific should be considered in portfolio construction and management by international property investors, to reduce or mitigate the interest rate risk in the region.

This and the preceding chapters have demonstrated the existence of REIT specialisation value in the Asia-Pacific by comparing different property types of REITs with diversified REITs from the aspect of interest rate sensitivity. To validate the specialisation value in the Asia-Pacific region, the next chapter will extend these analyses to assess risk-return attributes of sector-specific REITs in the USA, the largest REIT market globally.

Table 8-19: Asia-Pacific sector-specific REIT interest rate sensitivity summary

Are Asia-Pacific sector-specific REITs sensitive to movements in the level and volatility of short- and long-term interest rates?		1	2	3	4	5	6
Panel A: Whole period							
Japan	IR3m	✕	✕	✔	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✔
	IR10y	✕	✕	✔	✔	✕	✔
	IR10y Vol.	✕	✕	✕	✕	✕	✕
Australia	IR3m	✕	✕	✕	✕	✕	✕
	IR3m Vol.	✔	✕	✕	✕	✕	✔
	IR10y	✕	✕	✕	✕	✕	✔
	IR10y Vol.	✕	✔	✕	✔	✕	✔
Singapore	IR3m	✕	✕	✕	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✔
	IR10y	✕	✕	✕	✕	✕	✕
	IR10y Vol.	✕	✕	✕	✕	✕	✕
Panel B: Pre-GFC							
Japan	IR3m	✕	✕	✕	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✔
	IR10y	✔	✔	✔	✔	✔	✔
	IR10y Vol.	✕	✕	✕	✕	✕	✕
Australia	IR3m	✔	✔	✔	✕	✕	✔
	IR3m Vol.	✕	✕	✔	✕	✕	✕
	IR10y	✔	✕	✔	✕	✔	✔
	IR10y Vol.	✕	✕	✔	✕	✕	✕
Singapore	IR3m	✕	✔	✕	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✕
	IR10y	✕	✔	✕	✕	✕	✕
	IR10y Vol.	✕	✕	✕	✕	✕	✕
Panel C: Post-GFC							
Japan	IR3m	✕	✔	✔	✔	✔	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✕
	IR10y	✕	✕	✔	✕	✔	✕
	IR10y Vol.	✕	✕	✕	✕	✕	✕
Australia	IR3m	✕	✕	✕	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✔
	IR10y	✕	✕	✕	✕	✕	✕
	IR10y Vol.	✕	✕	✕	✔	✕	✕
Singapore	IR3m	✕	✕	✕	✕	✕	✕
	IR3m Vol.	✕	✕	✕	✕	✕	✕
	IR10y	✕	✕	✕	✕	✕	✕
	IR10y Vol.	✕	✕	✕	✕	✕	✕

Note: 1 = Office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty, 6 = diversified

CHAPTER 9
VALIDATION AGAINST SECTOR-SPECIFIC REITS IN THE USA

Chapter 9 validates the REIT specialisation value on the US-REIT market from July 2006 to December 2018, including the pre-GFC and post GFC timeframes. Risk-adjusted performance, portfolio diversification benefits, optimal and constrained mixed-asset portfolios, interest rate sensitivity and sub-period analyses are assessed for all US-REIT sub-sectors – office, retail, industrial, residential and specialty REITs, as well as diversified US-REITs. The results of the performance and portfolio analyses in this chapter have been externally validated by the study of Lin et al. (2020), in which the investment performance, portfolio diversification benefits and roles in domestic mixed-asset portfolios of sector-specific US-REITs are assessed.

9.1 INTRODUCTION

The primary purpose of this chapter is to validate the existence of REIT specialisation value in the Asia-Pacific (RQ6). The specialisation value has been asserted in the finance literature, positing that a single-business segment trades at a premium over their diversified counterparts (Hyland and Diltz, 2002; Villalonga, 2004). This implies sector-specific REITs will be a more effective listed property investment channel for REIT investors than diversified REITs. This is also consistent with the trend of institutional investors actively making their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than diversified REITs. Despite specialisation emerging as the preferable REIT structure for investors, it is unclear whether sector-specific REITs offer superior risk-adjusted returns, portfolio diversification benefits and portfolio returns, or lesser sensitivity to interest rate changes, in comparison with diversified REITs.

Chapters 5, 6 and 8 confirmed that Asia-Pacific sector-specific REITs provided that above advantages over diversified REITs in domestic, regional and international mixed-asset portfolios from July 2006 to December 2018. These analyses strongly validate the assertion of REIT specialisation value in the Asia-Pacific region.

However, a number of studies of the US-REIT market, the largest REIT market in the international context, appear to contradict the assertion of REIT specialisation value (Benefield *et al*., 2009; Ro and Ziobrowski, 2011). Given an adverse impact of the GFC upon the international REIT market (Kim, 2009; Newell and Peng, 2009; Newell and Razali, 2009; Peng and Lee, 2013; Lee *et al*., 2016), it is imperative to offer updated empirical evidence of REIT specialisation value in the USA in the post-GFC context. Unlike previous US studies – which, by taking different property types of REITs as a hybrid specialised REIT portfolio, disregard the fact that distinct property sectors may characterise various market cycles (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Chong *et al*., 2012; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a) – this study is the first to compare different property types of REITs with diversified REITs, and has comprehensive insights for property investors seeking listed property exposure in the Asia-Pacific region and the USA.

This chapter builds upon the analyses of the previous chapters to explore risk-adjusted returns, portfolio diversification benefits, risk-adjusted performance comparisons, roles in domestic mixed-asset portfolios and interest rate sensitivity of sector-specific US-REITs. The sub-period analysis was utilised to capture the dynamic investment performance of sector-specific US-REITs, and to reinforce the existence of REIT specialisation value in the USA. The timeframe was divided into two sub-periods: pre-GFC and post-GFC. The risk-adjusted return, correlation, efficient frontiers, asset allocation diagrams and interest rate sensitivity were investigated for each sub-period. This chapter is structured as follows. Section 9.2 explores risk-adjusted returns of sector-specific US-REITs. Section 9.3 examines the portfolio diversification benefits of different property types of US-REITs. Section 9.4 compares risk-adjusted returns of sector-specific and diversified US-REITs in the USA. Section 9.5 discusses the roles of different property types of REITs in the US mixed-asset portfolios, while Section 9.6 examines the interest rate sensitivity of sector-specific US-REITs. Finally, Section 9.7 summarises the findings of the chapter and offers concluding comments.

9.2 RISK-ADJUSTED PERFORMANCE ANALYSIS

Table 9-1 presents annual returns, annual risk and risk-adjusted returns for sector-specific US-REITs and diversified US-REITs, as well as the mainstream asset classes (stocks and bonds) in the USA from July 2006 to December 2018. In general, all property types of US-REITs (average 4.75% p.a.) offered higher average annual returns than diversified US-REITs (2.52% p.a.) over the full sample period, except industrial US-REITs (1.82%). The others were residential (8.07% p.a.), specialty (7.80% p.a.), retail (3.51% p.a.) and office US-REITs (2.53% p.a.). Among sector-specific US-REITs, residential US-REITs posted higher average annual returns than stocks (7.85% p.a.), while the other sector-specific were inferior to both stocks and diversified US-REITs. Nonetheless, both sector-specific and diversified US-REITs had greater average annual returns than bonds (1.91% p.a.), except for industrial US-REITs.

The risk levels for all property types of US-REITs were lower than for diversified US-REITs (average risk = 25.54%) over the full-time study period, except for industrial (38.72%) and retail US-REITs (27.67%). The others were specialty (20.65%), residential (23.04%) and office US-REITs (25.04%). Compared with the mainstream asset classes, both sector-specific and diversified US-REITs offered higher volatility than stocks (14.47%) and bonds (5.02%).

On a risk-adjusted return basis (via the Sharpe ratio), all property types of US-REITs significantly outperformed diversified US-REITs (0.06) – specialty (0.33), residential (0.31), retail (0.09) and office US-REITs (0.06). The only exception was industrial US-REITs (0.02). Both sector-specific and diversified US-REITs were topped by stocks (0.48), due to their high-risk levels over the entire study period. On the other hand, specialty and residential US-REITs were superior to bonds (0.20), while retail, office, industrial and diversified US-REITs struggled against bonds. The results clarify that different property types of US-REITs generally provided stronger average annual returns but higher risk level compared with diversified US-REITs. This implies that different property types of REITs generally outpaced diversified US-REITs on a risk-adjusted return basis from July 2006 to December 2018.

Table 9-1: Sector-specific US-REIT performance analysis*: July 2006–December 2018

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
REIT				
Office	2.53	25.04	0.06	6
Retail	3.51	27.67	0.09	5
Industrial	1.82	38.72	0.02	8
Residential	8.07	23.04	0.31	3
Specialty	7.80	20.65	0.33	2
Diversified	2.52	25.54	0.06	7
Stocks	7.85	14.47	0.48	1
Bonds	1.91	5.02	0.20	4

Note: *Local currency

9.3 DIVERSIFICATION BENEFIT ANALYSIS

Table 9-2 illustrates the inter-asset correlation matrix for sector-specific US-REITs, diversified US-REITs, stocks and bonds from July 2006 to December 2018. Residential ($r = 0.63$), industrial ($r = 0.66$) and retail US-REITs ($r = 0.67$) offered more potent diversification benefits with stocks than did diversified US-REITs (0.71), while specialty ($r = 0.76$) and office US-REITs ($r = 0.74$) marginally underperformed compared to diversified US-REITs. Additionally, different property types of US-REITs (average $r = -0.04$) provided greater diversification benefits with bonds than did diversified US-REITs ($r = -0.01$) over the study period. These were industrial ($r = -0.08$), office ($r = -0.03$), retail ($r = -0.03$), residential ($r = -0.03$) and specialty US-REITs ($r = -0.01$).

In terms of an inter-property investment strategy, diversification within various property types of US-REITs (average $r = 0.84$) was more attractive than diversification within each property type of US-REITs and diversified US-REITs (average $r = 0.88$). This is due to that a diversified REIT portfolio comprises multiple property sectors. The results confirm that different property types of US-REITs delivered higher portfolio diversification benefits than diversified US-REITs. This also suggests that a sectoral US-REIT investment strategy could provide greater portfolio diversification benefits for property investors than an inter-REIT investment strategy over the full study period.

Table 9-2: Sector-specific US-REIT correlations analysis: July 2006–December 2018

	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.09	1.00						
Diversified	0.71*	-0.01*	1.00					
Office	0.74*	-0.03*	0.93*	1.00				
Retail	0.67*	-0.03*	0.90*	0.92*	1.00			
Industrial	0.66*	-0.08	0.78*	0.84*	0.84*	1.00		
Residential	0.63*	-0.03*	0.86*	0.84*	0.82*	0.69*	1.00	
Specialty	0.76*	-0.02	0.91*	0.92*	0.90*	0.82*	0.85*	1.00

Note: *Significant correlation (p<5%)

9.4 RISK-ADJUSTED PERFORMANCE COMPARISON ANALYSIS

While the preceding sections have illustrated that different property types of US-REITs generally offered stronger risk-adjusted returns compared with their diversified counterparts, it is still unclear whether different property types of US-REITs and diversified US-REITs are statistically distinct on a risk-adjusted performance basis. The pairwise test was utilised to examine differential risk-adjusted performance between different property types of US-REITs and diversified US-REITs. **Table 9-3** depicts the risk-adjusted return comparison results for sector-specific and diversified US-REITs from July 2006 to December 2018. Most sector-specific US-REITs are statistically significant at the 1% level over the entire sample period, except for office US-REITs. This implies that there were substantial disparities in the Sharpe ratio between different property types of US-REIT and diversified US-REITs.

Specialty (Z value = 142.04), residential (138.72) and retail US-REITs (20.74) markedly outperformed diversified US-REITs, as the Z-test statistics of these three assets are positively and statistically significant at the 1% level. In contrast, industrial US-REITs (−26.88) offered poorer risk-adjusted returns than diversified US-REITs. This was evident from the Z-test statistics of the asset being negatively and statistically significant at the 1% level. However, office US-REITs (1.19) were insignificant compared with diversified US-REITs on the pairwise test. It can be clarified by the high correlation between office and diversified US-REITs ($r = 0.92$). In short, the results generally distinguish different property types of US-REITs as a distinct investment asset from diversified US-REITs on a risk-adjusted return basis. The results validate the existence of REIT specialisation value in the USA for property investors seeking listed property exposure in the USA over the entire study timeframe.

Table 9-3: Risk-adjusted performance comparison between sector-specific and diversified US-REITs: July 2006–December 2018

Portfolio	Office and Diversified	Retail and Diversified
Z-test	1.19	20.74***
Portfolio	Industrial and Diversified	Residential and Diversified
Z-test	−26.88***	138.72***
Portfolio	Specialty and Diversified	
Z-test	142.04***	

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

9.5 MIXED-ASSET PORTFOLIO ANALYSIS

Figure 9-1 plots the efficient frontiers and asset allocation diagram for an optimal multi-asset portfolio for different property types of US-REITs, diversified US-REITs, stocks and bonds from July 2006 to December 2018. Efficient frontiers with the inclusion of residential US-REITs significantly overtook the financial asset-only portfolio (stocks and bonds) and allowed for a wider risk-return band. Nonetheless, the addition of diversified US-REITs offered no conspicuous upward shift of the efficient frontier. This indicates that different property types of US-REITs not only delivered large increment of the efficient frontiers but also allowed for a wider risk-return scale, particularly for residential US-REITs. This indicates different property types of US-REITs were an important portfolio component for both risk-averse and risk-taking investors over the past 12 years.

Table 9-4 and **Figure 9-2** display the estimated optimal portfolio allocations of different property types of REITs and diversified US-REITs in domestic mixed-asset portfolios and the corresponding portfolio returns and risk level. Different property types of US-REITs (average allocation = 31.8% for residential US-REITs) featured across the entire risk-return range, displacing bonds (21.8%) in the lower end of the risk spectrum and stocks (46.4%) in the higher end of the risk-return scale. Nevertheless, diversified US-REITs did not play any role in the risk-return band. As the risk-return level increased, weighting of residential US-REITs began to increase. This resulted in a 100% portfolio allocation in residential US-REITs at the maximum portfolio risk level.

Figure 9-1: Sector-specific US-REIT efficient frontiers: July 2006–December 2018

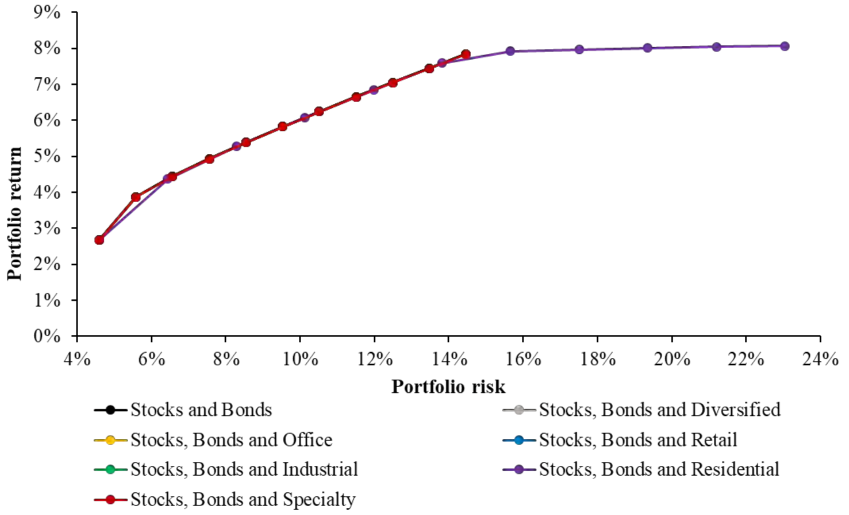
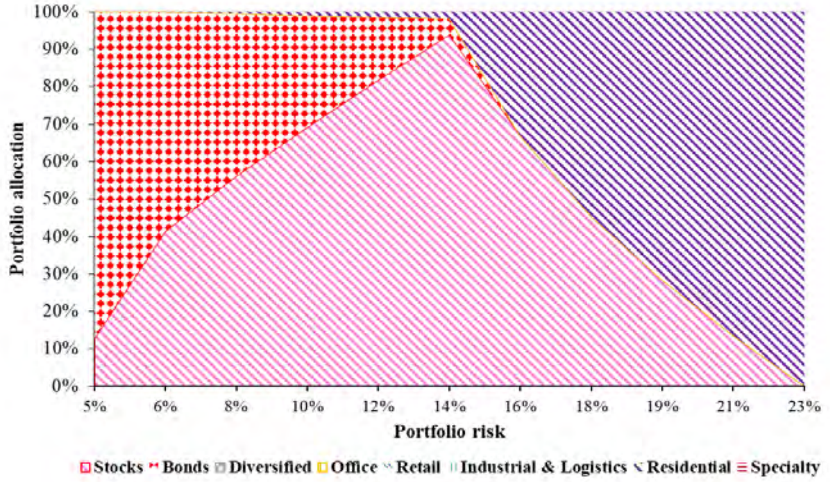


Table 9-4: Sector-specific US-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
12.8%	87.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.67%	4.59%
41.5%	58.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.38%	6.44%
56.2%	43.4%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	5.27%	8.28%
69.3%	29.8%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	6.08%	10.13%
81.8%	17.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.0%	6.84%	11.97%
93.9%	4.4%	0.0%	0.0%	0.0%	0.0%	1.7%	0.0%	7.59%	13.82%
67.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.0%	0.0%	7.92%	15.66%
45.4%	0.0%	0.0%	0.0%	0.0%	0.0%	54.6%	0.0%	7.97%	17.51%
28.5%	0.0%	0.0%	0.0%	0.0%	0.0%	71.5%	0.0%	8.01%	19.35%
13.7%	0.0%	0.0%	0.0%	0.0%	0.0%	86.3%	0.0%	8.04%	21.20%
0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	8.07%	23.04%

Figure 9-2: Sector-specific US-REIT asset allocation diagram: July 2006–December 2018

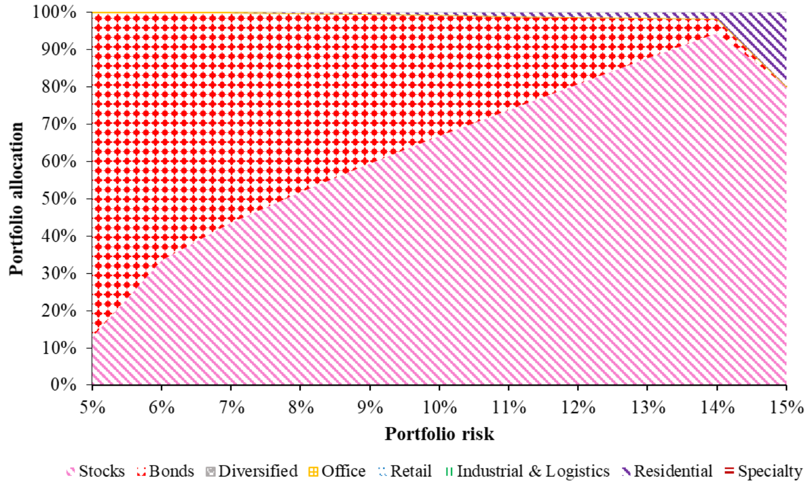


To avoid the over-exposure of the property asset class in mixed-asset portfolios, a constrained mean-variance analysis was conducted to assess the more practical portfolio weightings for property assets in a mixed-asset portfolio. This constrained portfolio analysis used an upper-bound constraint of 20% for the property asset classes. The results of this analysis are presented in **Table 9-5** and **Figure 9-3**. Residential US-REITs (average allocation = 2.5%) featured prominently across the whole risk-return band within the ambit of the 20% capped portfolio allocation to the property asset classes, while stocks (35.3%) and bonds (62.2%) had more active roles in structuring the capped portfolio allocation of the mixed-asset portfolio. Specifically, residential US-REITs increased their role in the higher end of the risk-return range, complementing both stocks and bonds. Diversified US-REITs did not play any role in constrained portfolio compositions. These analyses provide robust empirical evidence that sector-specific US-REITs offered superior portfolio returns to diversified US-REITs. These findings support sector-specific US-REITs as a more significant portfolio component, delivering higher portfolio returns in mixed-asset portfolios compared with diversified REITs over the full study period. Importantly, this supports the assertion of REIT specialisation value in the USA.

Table 9-5: Constrained sector-specific US-REIT asset allocation: July 2006–December 2018

Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty	Portfolio return	Portfolio risk
12.8%	87.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.67%	4.59%
33.5%	66.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.90%	5.63%
43.5%	56.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.49%	6.66%
51.8%	48.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	5.00%	7.70%
59.4%	40.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	5.47%	8.73%
66.8%	32.5%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	5.92%	9.76%
73.9%	25.1%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	6.36%	10.80%
80.8%	17.9%	0.0%	0.0%	0.0%	0.0%	1.3%	0.0%	6.78%	11.83%
87.6%	10.9%	0.0%	0.0%	0.0%	0.0%	1.5%	0.0%	7.21%	12.87%
94.4%	3.9%	0.0%	0.0%	0.0%	0.0%	1.7%	0.0%	7.62%	13.90%
80.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	7.89%	14.93%

Figure 9-3: Constrained sector-specific US-REIT asset allocation diagram: July 2006–December 2018



9.6 INTEREST RATE SENSITIVITY ANALYSIS

Table 9-7 details the descriptive statistics of excess returns of US-REIT sub-sectors from July 2006 to December 2018, as well as the measure for the skewness, kurtosis and Jarque-Bera normality test applied to the excess return series. The daily risk and return rankings are generally consistent with the monthly results reported in the previous sections. Positive skewness and excess kurtosis are witnessed for all US-REIT sub-sectors, disproving the null hypothesis of normal distribution based on the Jarque-Bera statistics. The dynamics of 3-month and 10-year interest rates are depicted in **Figure 9-4**.

The plots of daily excess returns for each US-REIT sub-sectors are displayed in **Figure 9-5**. A higher level of volatility for each US-REIT sub-sectors during 2007–2018 was witnessed, implying that the GFC timeframe was more volatile for all US-REIT sub-sector series. The time-varying excess returns for all US-REIT sub-sectors validates the volatility clustering effect over the entire study period. This suggests the potential of the GARCH approach for estimating the US-REIT sub-sector excess return series. To reinforce the fitness of the GARCH framework for all US-REIT sub-sectors, **Figure 9-6** illustrates the ACF test on both excess returns and the volatility for US-REIT sub-sector series, with the ACF displayed over 36 lags. Lower persistence in excess returns was shown compared with relatively strong persistence in the volatility series. The results are in line with the volatility clustering features of financial time series, particularly for daily REIT data used. As noted by Cotter and Stevenson (2007) and Stevenson *et al*. (2007), the results substantiate the existence of the ARCH effects for daily US-REIT excess returns and explain the suitability of the application of GARCH-related processes to daily US-REIT data series. This is confirmed by the LM tests, as presented in **Table 9-7**.

The ADF test was used for unit roots and stationarity of all US-REIT sub-sectors, the market equity index, 3-month and 10-year interest rate series over the entire study period, as well as the conditional variances of the market equity index and the 3-month and 10-year interest rates. As documented in **Table 9-6**, the ADF tests on the level form show that the computed t-statistics for all variables did not indicate the presence of unit roots. The only exception was the 10-year interest rate series. Therefore, the ADF test was extended on first differences for all variables, resulting in all variables strongly disproving the null hypothesis at 1% significance. This shows that all series are appropriate for further analysis of time-varying return and volatility transmissions.

Table 9-6: ADF unit test for US-sector-specific REITs: July 2006–December 2018

	Level		First differences		
Variable	*t*-statistics	*p*-value	*t*-statistics	*p*-value	Stationary
Diversified	−68.248	0.000	−26.439	0.000	*I*(0)
Office	−47.250	0.000	−17.548	0.000	*I*(0)
Retail	−67.591	0.000	−26.500	0.000	*I*(0)
Industrial	−61.732	0.000	−18.840	0.000	*I*(0)
Residential	−69.447	0.000	−19.529	0.000	*I*(0)
Specialty	−70.113	0.000	−27.395	0.000	*I*(0)
Market	−44.787	0.000	−21.836	0.000	*I*(0)
IR 3m	−2.804	0.005	−22.611	0.000	*I*(0)
IR 10y	−2.549	0.104	−60.203	0.000	*I*(1)
Market Vol.	−5.254	0.000	−10.730	0.000	*I*(0)
IR 3m Vol.	−16.320	0.000	−25.635	0.000	*I*(0)
IR 10y Vol.	−12.367	0.000	−20.591	0.000	*I*(0)

Note: H_0-non-stationary

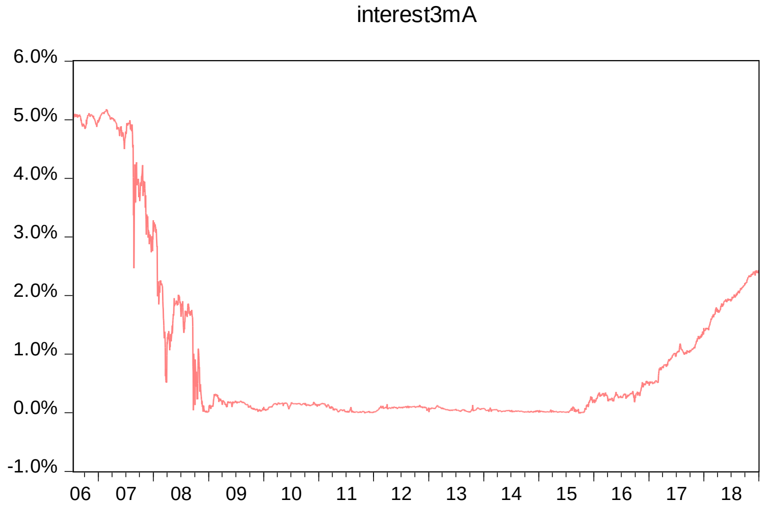
Table 9-7: Summary statistics for US sector-specific REITs: July 2006–December 2018

	Diversified	**Office**	**Retail**	**Industrial**	**Residential**	**Specialty**
Mean(%)	0.008	0.026	0.042	0.033	0.052	0.058
Median(%)	0.000	0.000	0.000	0.006	0.027	0.047
Maximum(%)	21.599	20.118	21.676	13.114	16.281	18.246
Minimum(%)	−19.932	−19.866	−23.643	−24.425	−19.464	−16.659
Standard deviation(%)	2.510	2.251	2.043	1.745	2.186	2.108
Skewness	0.337	0.450	0.454	−0.893	0.206	0.579
Kurtosis	16.647	18.804	24.300	22.318	16.026	15.487
Jarque-Bera	25,273.85***	33,920.14***	61,527.17***	50,951.65***	22,994.31***	21,289.46***
LM test	145.903***	353.606***	128.854***	49.951***	361.926***	321.083***

Note: * Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

Figure 9-4: 3-month and 10-year interest rates in the USA: July 2006–December 2018

3-month interest rates



10-year interest rates

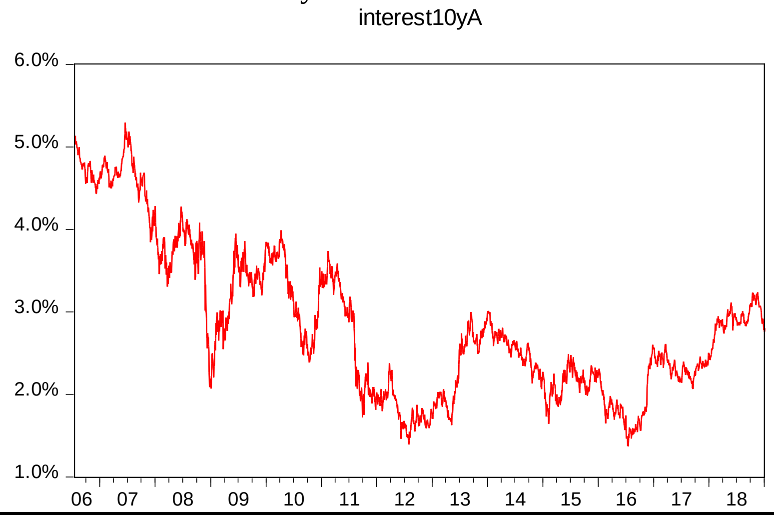


Figure 9-5: Excess returns for US sector-specific REITs: July 2006–December 2018

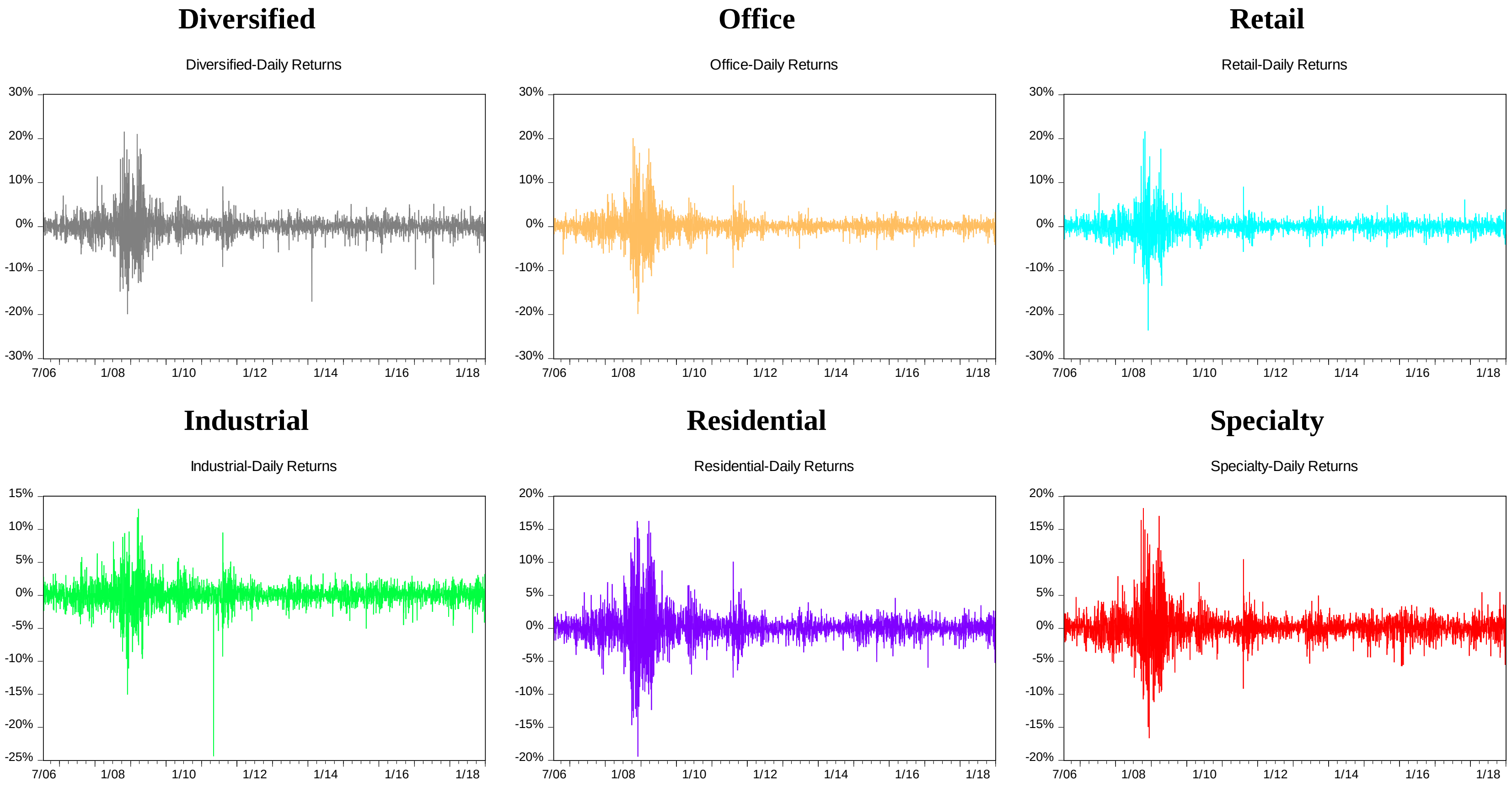


Figure 9-6: Autocorrelation plots for excess returns and volatility of US sector-specific REITs: July 2006–December 2018

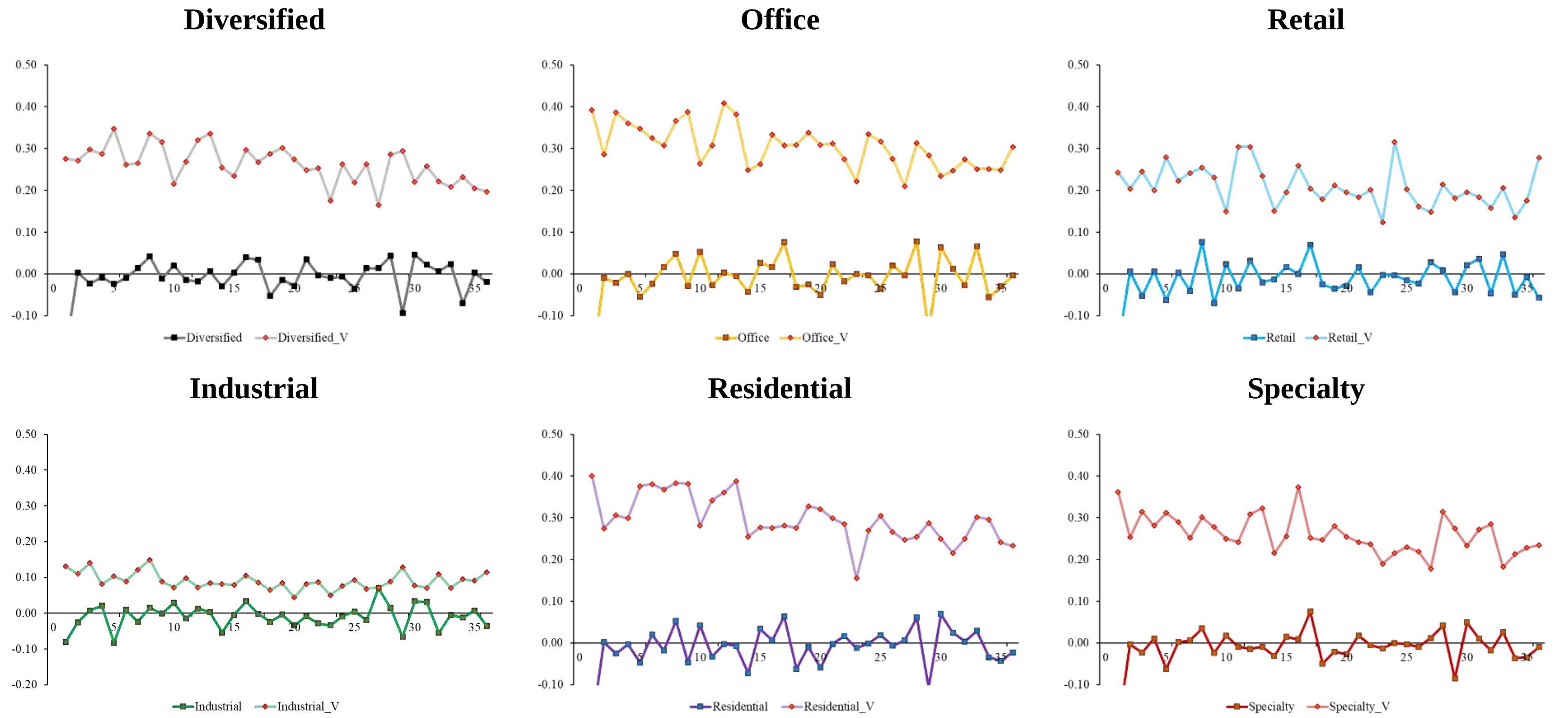


Table 9-8 articulates the coefficients for the main GARCH-M model over the full study timeframe, using the 3-month and 10-year interest rates. The coefficient of the GARCH term (θ_j) for five out of six US-REIT sub-sectors was insignificant, while the signs of industrial REITs were significant and negative. As previously discussed, the insignificant coefficients for office, retail, residential, specialty and diversified REITs indicate the lack of a risk-return trade-off for these five US-REIT sub-sectors over the entire study period. However, the negative sign of industrial REITs implies it was less affected by the total risk than the other investment assets in the marketplace. This is supported by the lower correlation with stocks of industrial REITs ($r = 0.66$) compared with the other sector-specific and diversified REIT, as reported in the previous sections. The results disprove the null hypothesis of $\theta_j = 0$ (H_1). To examine the presence of ARCH and GARCH effects, hypothesis 2 was tested. The results disprove the null hypothesis of $\alpha_j = \beta_j = v_{1j} = v_{2j} = 0$ and indicate that the volatility of excess returns was time-variant. Hypotheses 3 ($\theta_j = \beta_j = v_{1j} = v_{2j} = 0$), 4 ($\beta_j = v_{1j} = v_{2j} = 0$) and 5 ($\theta_j = v_{1j} = v_{2j} = 0$) measure whether the return-generating process serves ARCH, ARCH-M and GARCH specifications, respectively. The results disprove the null hypotheses of these three hypotheses. However, these findings contradict the initial finding that volatility is not a significant factor in excess returns. Higher excess returns of all US-REIT sub-sectors were witnessed as increases in both excess returns and the volatility of the market equity. The results disprove the null hypothesis of $v_{1j} = 0$ (H_6), and indicate the significant influence of market equity on excess returns of all US-REIT sub-sector series over the whole study timeframe.

The main findings regarding the interest rate sensitivity of all US-REIT sub-sectors provide weaker evidence of the mean equation than the variance equation. Increases in the 10-year interest rate level were associated with high returns of retail, residential and diversified REITs. Meanwhile, increases in the 3-month interest rate level were related to higher returns of industrial REITs. In addition, higher excess returns of diversified REITs were related to increases in the 3-month interest rate volatility, while specialty REITs was influenced by the 10-year interest rate volatility. The interest findings are the positive μ_j for these five US-REIT sub-sectors. This is in line with the findings of Stevenson *et al*. (2007) and Lee *et al*. (2014), which documented the positive significance of the sensitivity of the listed property markets in the USA, the UK, Germany and the Netherlands to interest rate changes during the period of lower interest rate volatility in these four markets. Reflecting the study timeframe, a historically low interest rate level has been widely reported since the GFC, and many central banks have employed QE to stimulate domestic economic expansion. On the other hand, office REITs was the only sector-specific US-REITs immune to changes in the level and volatility of both the 3-month and 10-year interest rate series. Since the parameter β_j for all US-REIT sub-sectors was considerably larger than the values of α_j, the long memory of US-REIT sub-sectors has been confirmed.

The overall picture from these analyses is that changes in the level of 10-year interest rates affected excess returns of retail, industrial, residential and diversified REITs, and movements in the level of 3-month interest rates influenced excess returns of specialty REITs. Additionally, increases in the volatility of 3-month interest rates, as measured by changes in the conditional variance of 3-month interest rates, were associated with higher excess returns of diversified REITs. Increases in the volatility of 10-year interest rates were related to higher excess returns of specialty REITs. However, office REITs was unaffected by the level and volatility of both short- and long-term interest rates. The lack of significance of the short- and long-term interest rate volatility effects on excess returns of office REITs may indicate that sector-specific REITs were less sensitive to interest rate changes, owing to stronger risk aversion and hedging actions of different property types of REITs compared with their diversified counterparts over the full sample period.

Table 9-8: GARCH-M model for sector-specific US-REITs: July 2006–December 2018

	Diversified		**Office**		**Retail**	
	3M	10Y	3M	10Y	3M	10Y
Mean equation						
Const	−0.040(−1.169)	−0.022(−1.177)	−0.033(−1.409)	−0.098(−1.832)*	−0.000(−0.003)	−0.052(−0.901)
Garch term	−0.004(−0.259)	−0.020(−0.878)	−0.009(−0.549)	−0.003(−0.206)	−0.013(−0.737)	−0.017(−0.962)
Market	1.139(59.424)***	0.286(27.406)***	0.987(65.381)***	0.988(65.706)***	0.759(41.570)***	0.759(41.554)***
IR	−0.005(−0.360)	0.068(2.470)**	−0.008(−0.754)	0.026(1.322)	−0.004(−0.293)	0.020(1.873)*
Variance equation						
Const	0.058(6.950)***	0.019(4.511)***	0.010(6.008)***	0.011(6.261)***	0.012(3.143)***	0.012(3.146)***
Arch	0.078(23.684)***	0.155(9.382)***	0.043(7.146)***	0.043(7.135)***	0.038(3.920)***	0.038(3.913)***
Garch	0.906(90.706)***	0.842(63.096)***	0.950(163.361)***	0.950(161.176)***	0.956(131.876)***	0.955(131.249)***
Market Vol	0.022(1.988)**	0.029(2.080)**	0.031(1.969)**	0.033(2.130)**	0.033(2.551)**	0.036(1.685)*
IR Vol	0.096(2.661)**	−44.708(−1.002)	0.026(0.223)	−71.119(−0.541)	0.079(0.281)	−45.157(−0.298)
	Industrial		**Residential**		**Specialty**	
Mean equation						
Const	0.060(0.025)	0.105(2.045)**	0.001(0.040)	−0.004(−0.160)	0.001(0.022)	−0.001(−0.031)
Garch term	−0.003(−2.164)**	0.009(0.342)**	−0.031(−1.264)	−0.034(−1.469)	−0.017(−0.896)	−0.014(−0.744)
Market	0.872(55.143)***	0.871(55.127)***	0.275(31.451)***	0.274(31.124)***	0.348(29.622)***	0.347(29.699)***
IR	0.042(1.800)*	0.039(2.184)**	0.042(0.528)	0.055(1.823)**	−0.005(−0.050)	0.061(1.539)
Variance equation						
Const	0.016(3.948)***	0.017(3.953)***	0.007(5.829)***	0.007(5.849)***	0.006(5.488)***	0.005(5.267)***
Arch	0.041(6.185)***	0.041(6.190)***	0.077(8.444)***	0.078(8.566)***	0.053(8.678)***	0.052(8.674)***
Garch	0.947(122.632)***	0.946(121.568)***	0.919(218.521)***	0.918(215.635)***	0.946(331.471)***	0.947(332.298)***
Market Vol	0.009(4.557)***	0.009(4.571)***	0.038(3.143)***	0.043(3.472)***	0.044(2.868)***	0.049(3.225)***
IR Vol	0.051(0.190)	−50.118(−0.255)	0.586(0.049)	−63.188(−1.405)	−0.211(−0.001)	−153.940(−2.047)**

9.7 SUB-PERIOD ANALYSIS

To assess the dynamic performance and time-changing nature of sector-specific US-REITs, the full study period of July 2006–December 2018 was broken down to two sub-periods of July 2006–September 2007 (pre-GFC) and July 2009–December 2018 (post-GFC). **Table 9-9** exhibits the sub-period risk-adjusted returns of sector-specific US-REITs, diversified US-REITs and the mainstream asset classes over the two sub-periods. Sector-specific US-REITs consistently provided stronger risk-adjusted returns than diversified US-REITs and bonds over the two sub-periods, particularly in the post-GFC context. Stocks was the best risk-adjusted performer in the US context over two sub-periods, due to their comparatively higher annual returns and relatively lower annual risk compared with sector-specific US-REITs. Before the GFC (Panel A), sector-specific US-REITs provided lower average annual returns (10.31% p.a.) and higher risk level (average annual risk = 19.60%) than stocks (18.82% p.a.; 7.80%). This resulted in all property types of US-REITs struggling against stocks on a risk-adjusted return basis. After the GFC (Panel B), different property types of US-REITs generally offered higher average annual returns (13.93% p.a.) but comparatively higher volatility (18.02%) than stocks (12.73% p.a.; 12.31%), particularly for the resurgence in residential US-REITs (17.49% p.a.). This caused sector-specific US-REITs to marginally underperform stocks in terms of risk-adjusted returns in the post-GFC context.

Table 9-10 presents the sub-period correlations for sector-specific US-REITs, diversified US-REITs and the mainstream asset classes. Before the GFC, sector-specific US-REITs offered slightly higher diversification benefits with both stocks (average $r = 0.61$) and bonds (average $r = -0.47$) compared with the benefits of diversified US-REITs over stocks ($r = 0.61$) and bonds ($r = -0.55$). After the GFC, the portfolio diversification benefits of both stocks (average $r = 0.62$) and bonds (average $r = 0.18$) over sector-specific US-REITs were greater than the equivalent benefits with stocks ($r = 0.67$) and bonds ($r = 0.19$) for diversified US-REITs. These analyses show the consistent inter-asset correlations between two sub-periods.

Diversification within each property type of US-REITs and diversified US-REITs (average r = 0.82) during the pre-GFC period was stronger than its post-GFC level (average $r = 0.86$). Similarly, diversification within various property types of US-REITs (average r = 0.79) before the GFC was more attractive for investors than its post-GFC level (average *r* = 0.82). In sum, different property types of US-REITs generally offered more desirable diversification benefits with both stocks and bonds for property investors than did diversified US-REITs over both sub-periods. Importantly, a sectoral US-REIT investment strategy could provide more diversification benefits for the US listed property investors compared with an inter-REIT investment strategy over two sub-periods.

Table 9-9: Sector-specific US-REIT sub-period performance analysis*

Asset classes	Average annual return (%)	Annual risk (%)	Sharpe ratio	Rank
Panel A: Pre-GFC: July 2006–September 2007				
REITs				
Office	4.28	19.09	−0.02	6
Retail	15.87	21.87	0.51	4
Industrial	15.39	18.41	0.58	3
Residential	1.39	21.82	−0.15	7
Specialty	14.62	16.81	0.59	2
Diversified	7.12	13.61	0.18	5
Stocks	18.82	7.80	1.81	1
Bonds	4.07	0.96	−0.66	8
Panel B: Post-GFC: July 2009–December 2018				
REITs				
Office	10.22	17.85	0.55	6
Retail	13.10	18.03	0.70	5
Industrial	16.57	21.42	0.76	4
Residential	17.49	17.60	0.97	2
Specialty	12.25	15.18	0.78	3
Diversified	9.81	17.57	0.54	7
Stocks	12.73	12.31	1.00	1
Bonds	1.29	3.60	0.25	8

Note: *Local currency

Table 9-10: Sector-specific US-REIT sub-period correlations analysis

Panel A: Pre-GFC: July 2006–September 2007								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	-0.43*	1.00						
Diversified	0.61	-0.55	1.00					
Office	0.66	-0.56	0.83*	1.00				
Retail	0.54	-0.52	0.80*	0.89*	1.00			
Industrial	0.49	-0.34	0.88*	0.75*	0.85*	1.00		
Residential	0.71	-0.33	0.73*	0.77*	0.69*	0.66*	1.00	
Specialty	0.65	-0.58	0.84*	0.90*	0.85*	0.73*	0.80*	1.00
Panel B: Post-GFC: July 2009–December 2018								
	Stocks	Bonds	Diversified	Office	Retail	Industrial	Residential	Specialty
Stocks	1.00							
Bonds	0.08*	1.00						
Diversified	0.67*	0.19*	1.00					
Office	0.68*	0.18*	0.93*	1.00				
Retail	0.57*	0.23*	0.86*	0.87*	1.00			
Industrial	0.70*	0.09*	0.80*	0.84*	0.78*	1.00		
Residential	0.48*	0.24*	0.83*	0.83*	0.78*	0.71*	1.00	
Specialty	0.69*	0.14*	0.89*	0.88*	0.84*	0.83*	0.81*	1.00

Note: *Significant correlation (p<5%)

The sub-period asset allocations and efficient frontiers of different property types of US-REITs over two sub-periods are displayed in **Figure 9-7** and **Figure 9-8**, respectively. Before the GFC, the efficient frontiers containing different property types of US-REITs offered slightly greater portfolio returns than the addition of diversified US-REIT and financial asset-only portfolios, particularly for specialty US-REITs. The constrained multi-asset portfolio was strongly dominated by stocks and bonds, while minor roles for specialty and retail US-REITs were found at the start of the risk-return spectrum. After the GFC, the addition of sector-specific US-REITs and diversified US-REITs was clearly greater than that for the financial asset-only portfolio. Specifically, the efficient frontiers with the inclusion of different property types of US-REITs enhanced more portfolio returns than diversified US-REITs, except for retail US-REITs. Residential US-REITs figured prominently across the broad risk-return range within the ambit of the 20% capped total property allocation. Diversified US-REITs did not play any role within the constrained multi-asset portfolio.

Figure 9-7: Sector-specific US-REIT constrained asset allocation diagram and efficient frontiers: pre-GFC: July 2006–September 2007

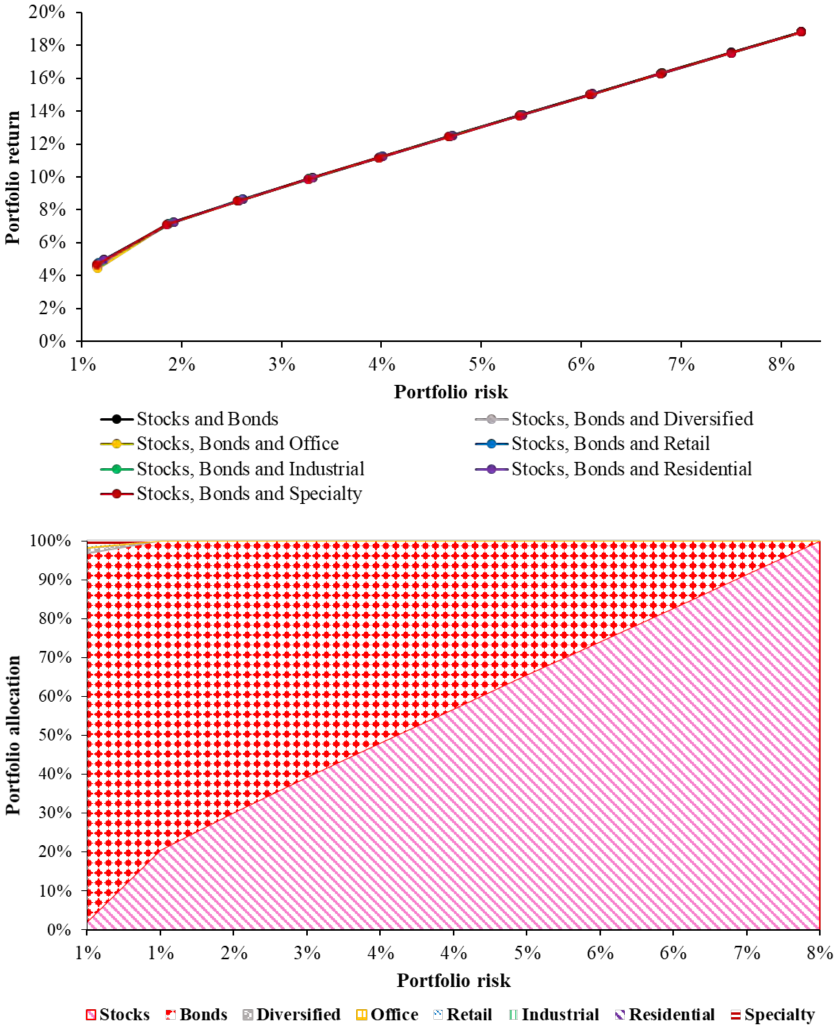
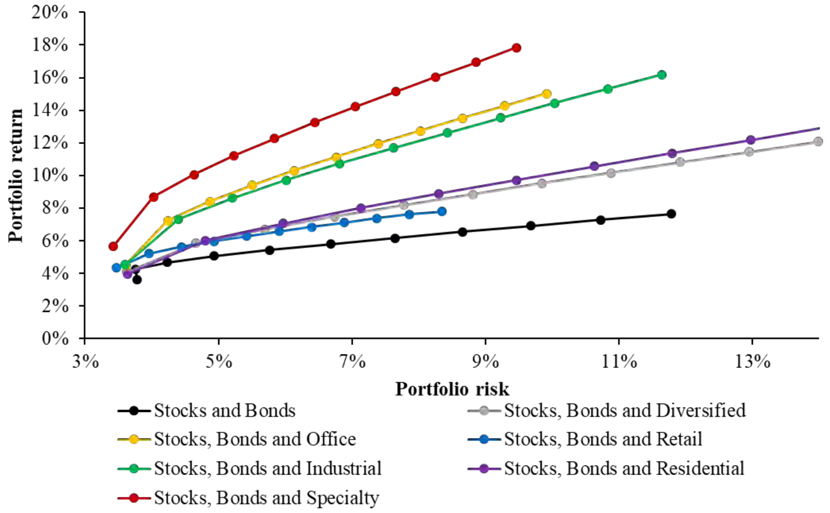
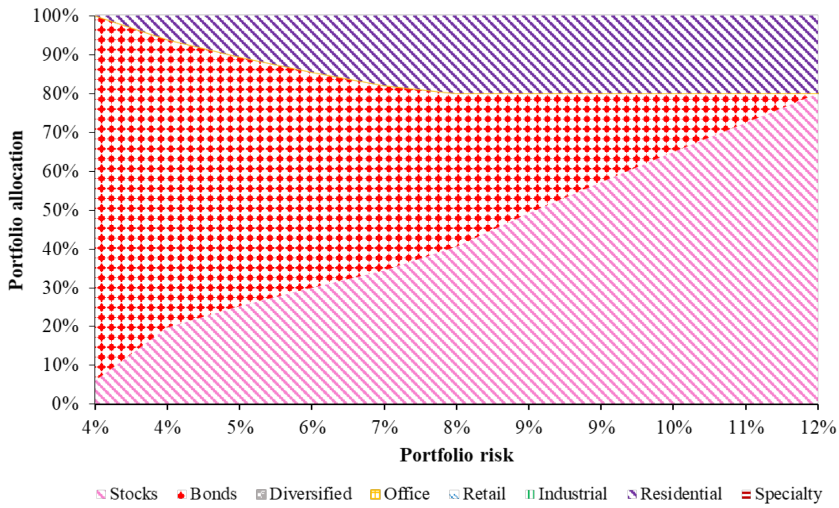


Figure 9-8: Sector-specific US-REIT constrained asset allocation diagram and efficient frontiers: post-GFC: July 2009–December 2018





To assess the interest rate sensitivity of sector-specific and diversified REITs, the following analyses document the summary statistics, ADF unit test and main GARCH-M test for all US-REIT sub-sector series over two sub-periods. **Table 9-12** lists the descriptive statistics of all US-REIT sub-sectors over two sub-periods, including two sub-periods. Prior to the GFC, positive skewness is documented for retail, industrial, residential, specialty and diversified REITs, while negative skewness is only presented for office REITs. Excess kurtosis is documented for all US-REIT sub-sector distributions, disproving the null hypothesis of the normal distribution undertaken by the Jarque-Bera test. Post to the GFC, negative skewness is documented for office industrial, specialty and diversified REITs, while positive skewness is reported for retail and residential REITs.

Excess kurtosis is documented for all US-REIT sub-sector distributions. Based on the Jarque-Bera statistics, all US-REIT sub-sectors disprove the null hypothesis of the normal distribution. **Figure 9-9** and **Figure 9-10** portray the plots of daily excess returns for each US-REIT sub-sector over two sub-periods, respectively. The suitability of the GARCH framework for each US-REIT sub-sector series is reinforced by **Figure 9-6**, as reported in the previous section. The results display the ACF test on both excess returns and the volatility for all US-REIT sub-sector series, with the ACF displayed over 36 lags. This confirms the suitability of the GARCH framework for each US-REIT sub-sector series over two sub-periods.

Table 9-11 presents the stationarity test results of for all US-REIT sub-sectors and market equity index, as well as 3-month (IR 3m) and 10-year interest rate series (IR 10y) over two sub-periods: the pre-GFC (Panel A) and post-GFC periods (Panel B), with the respective volatility of the market equity index, 3-month and 10-year interest rates. Prior to the GFC, the results of the unit root test at the level show that the null hypothesis of unit root presence in the time-series cannot be rejected at all confidence levels for both the 3-month and 10-year interest rate series, and the volatility of the market equity. In contrast, the t-statistics computed for all US-REIT sub-sector series and the other variables were statistically significant at a 1% level. When the time series for variables were stated in first differences, all variables disproved the null hypothesis at a 1% significance level, as reported in **Table 9-12**.

Post-GFC, apart from the 3-month and 10-year interest rate series, the ADF tests on the level form show that the computed t-statistics for all variables do not indicate the presence of unit roots. Hence, the alternative hypothesis of no unit root must be accepted for these variables. Nonetheless, the t-statistic computed for two interest rate series did not correspond to any of the common statistical measurements. From this, it can be concluded that the unit root was present in the two interest rate series. When the ADF test was extended to first differences for all variables, the results of all variables strongly disproved the null hypothesis at a 1% significance level. In brief, the ADF test shows the time series over two sub-periods are appropriate for further analysis of time-varying return and volatility transmissions.

Table 9-11: Sub-period summary statistics for US sector-specific REITs

	Diversified		Office		Retail	
	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC	Pre-GFC	Post-GFC
Mean(%)	0.035	−0.002	−0.010	0.030	0.066	0.039
Median(%)	0.000	0.000	0.002	0.022	0.000	0.000
Minimum(%)	7.060	9.126	3.984	9.383	7.594	9.069
Maximum(%)	−6.320	−17.111	−6.352	−9.374	−3.923	−5.782
Standard deviation(%)	1.669	1.625	1.415	1.295	1.395	1.247
Skewness	0.199	−0.786	−0.404	−0.205	0.512	0.264
Kurtosis	4.808	12.391	4.586	7.579	5.847	6.526
Jarque-Bera	40.97***	9,199.31***	37.89***	2,143.94***	109.45***	1,289.40***
	Industrial		**Residential**		**Specialty**	
Mean	−0.003	0.038	−0.006	0.066	0.044	0.048
Median	0.000	0.036	0.000	0.062	0.047	0.052
Minimum	5.800	9.521	5.473	10.105	4.739	10.470
Maximum	−4.381	−24.425	−4.026	−7.486	−3.738	−9.167
Standard deviation	1.309	1.359	1.318	1.361	1.413	1.381
Skewness	0.325	−2.491	0.206	0.002	0.122	−0.126
Kurtosis	5.066	48.496	4.376	7.108	3.692	6.991
Jarque-Bera	56.08***	212,525.20***	24.68***	1,711.93***	6.44***	1,622.16***

Figure 9-9: Excess returns for US sector-specific REITs: pre-GFC: July 2006–September 2007

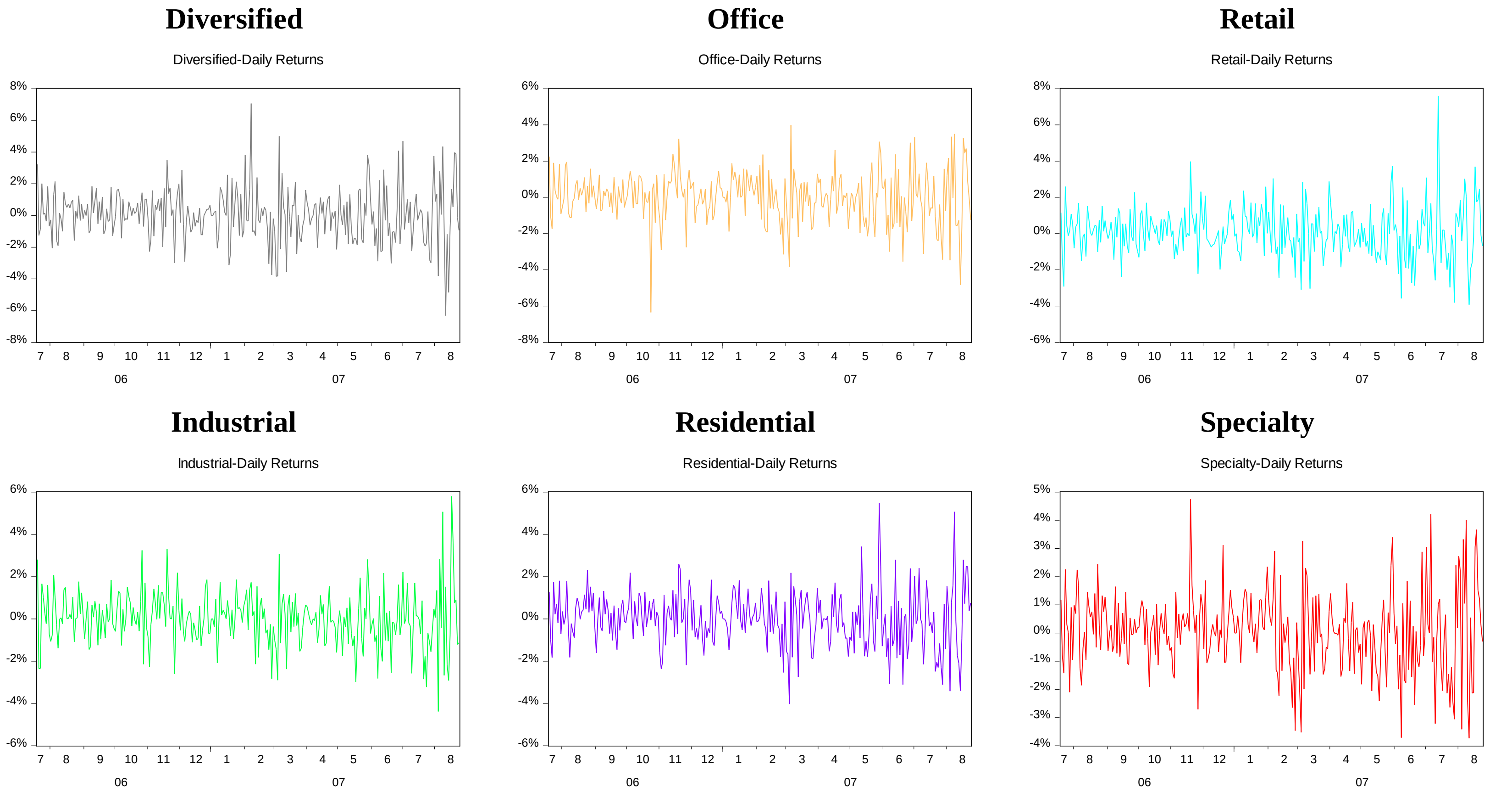


Figure 9-10: Excess returns for US sector-specific REITs: post-GFC: July 2009–December 2018

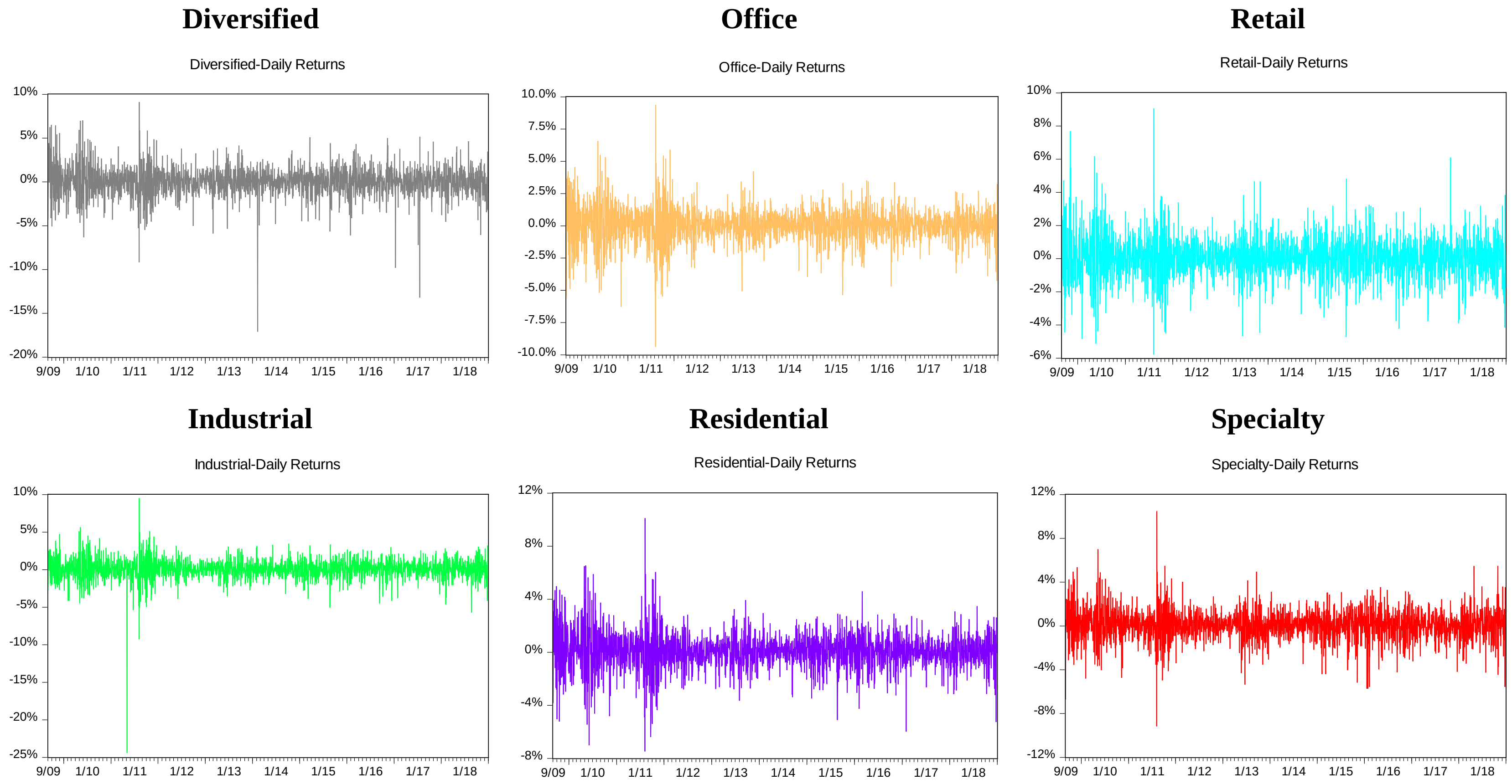


Table 9-12: Sub-period ADF unit test for US sector-specific REITs

Variable	Level		First differences		Stationary
	t-statistics	*p*-value	*t*-statistics	*p*-value	
Panel A: Pre-GFC: July 2006–September 2007					
Diversified	−15.896	0.000	−9.871	0.000	$I(0)$
Office	−14.682	0.000	−12.008	0.000	$I(0)$
Retail	−15.504	0.000	−10.784	0.000	$I(0)$
Industrial	−15.303	0.000	−11.540	0.000	$I(0)$
Residential	−13.933	0.000	−12.625	0.000	$I(0)$
Specialty	−13.740	0.000	−11.351	0.000	$I(0)$
Market	−17.311	0.000	−10.675	0.000	$I(0)$
IR 3m	−2.132	0.525	−14.100	0.000	$I(1)$
IR 10y	−2.271	0.182	−19.238	0.000	$I(1)$
Market Vol.	−1.801	0.380	−16.806	0.000	$I(1)$
IR 3m Vol.	−16.656	0.000	−16.607	0.000	$I(0)$
IR 10y Vol.	−3.403	0.012	−28.153	0.000	$I(0)$
Panel B: Post-GFC: July 2009–December 2018					
Diversified	−51.129	0.000	−25.002	0.000	$I(0)$
Office	−52.638	0.000	−25.067	0.000	$I(0)$
Retail	−52.012	0.000	−19.589	0.000	$I(0)$
Industrial	−51.344	0.000	−24.384	0.000	$I(0)$
Residential	−52.782	0.000	−24.773	0.000	$I(0)$
Specialty	−53.171	0.000	−24.875	0.000	$I(0)$
Market	−51.335	0.001	−20.102	0.000	$I(0)$
IR 3m	5.432	1.000	−7.137	0.000	$I(1)$
IR 10y	−2.300	0.172	−52.408	0.000	$I(1)$
Market Vol.	−5.126	0.000	−30.911	0.000	$I(0)$
IR 3m Vol.	−8.180	0.000	−16.886	0.000	$I(0)$
IR 10y Vol.	−5.770	0.000	−47.521	0.001	$I(0)$

Note: H_0-non-stationary

Table 9-13 tabulates the main findings of the interest rate sensitivity of all US-REIT sub-sectors measured by the GARCH-M framework over two sub-period timeframes, including two sub-periods, utilising both the 3-month and 10-year interest rate series. Prior to the GFC, the parameter θ_j in the mean equation was only significant for residential REITs, while the other sector-specific and diversified REITs were insignificant. For residential REITs, the results are consistent with the features of the financial time series reported by the mainstream financial economy and property literature. Nevertheless, the insignificant signs for the other sector-specific and diversified REITs imply that these five US-REIT sub-sectors were short of a risk-return trade-off, as stated by Elyasiani and Mansur (1998). Hypothesis 6 examines whether the market equity is a significant factor in excess returns of US-REIT sub-sectors. The significant impact of changes in excess returns of the market equity was witnessed for all US-REIT sub-sectors. Furthermore, excess returns of retail, industrial, specialty and diversified REITs were affected by fluctuations in the volatility of the market equity. This shows that the market equity had a great influence on excess returns of all US-REIT sub-sectors in the pre-GFC investment context, disproving the null hypothesis of $v_{1j} = 0$ (H_6).

In terms of the interest rate sensitivity of US-REIT sub-sectors, the results show stronger evidence of the mean equation than the variance equation. Specifically, changes in the 3-month interest rate level affected excess returns of retail and industrial REITs. Meanwhile, movements in the 10-year interest rate level influenced excess returns of retail, residential and diversified REITs. One interesting finding is the positive sign of the coefficients (μ_j and v_{2j}) in the mean and variance equations for these US-REIT sub-sectors. This is in stark contrast to the findings of the mainstream property literature claiming a negative linkage between excess returns of property companies and interest rates, given debt costs, yields and the general economic impact of interest rates on demand in the property sector (Bredin *et al.*, 2011). However, similar results were documented by Stevenson *et al*. (2007) and Lee *et al*. (2014), who reported the positive significance of the sensitivity of the listed property markets in the USA, the UK, Germany and the Netherlands to interest rate changes during the period of lower interest rate volatility. Compared with the mean equation, excess returns for retail REITs were influenced by movements in the volatility of the 3-month interest rate series prior to the GFC.

Post to the GFC, the parameter θ_j was insignificant for all US-REIT sub-sectors. This indicates that all US-REIT sub-sector series lacked a risk-return trade-off, as noted by Elyasiani and Mansur (1998). In addition, all US-REIT sub-sectors were highly affected by changes in excess returns of the market equity. Furthermore, excess returns of all US-REIT sub-sectors were more sensitive to fluctuations in the volatility of market equity compared with pre-GFC levels. In general, this shows that the market equity had a higher level of impact on excess returns of all US-REIT sub-sectors in the post-GFC investment context, disproving the null hypothesis of $v_{ij} = 0$ (H_6). For the main findings regarding the interest rate sensitivity of US-REIT sub-sectors, the results offer stronger evidence of the mean equation than the variance equation. Specifically, increases in the 10-year interest rate level were associated with higher returns of retail, residential and diversified

REITs. At the same time, office, industrial and specialty REITs were unaffected by changes in the level and volatility of both the 3-month and 10-year interest rate series. This is an interesting finding in the post-GFC investment context. The positive μ_j for retail, residential and diversified REITs on 10-year interest rates is highly counterintuitive, given that the mainstream property literature documents a negative relationship between interest rates and the property excess returns. Nevertheless, such results may be found in periods of lower interest rate volatility, as stated by Stevenson *et al*. (2007) and Lee *et al*. (2014). In particular, the application of QE by central banks has been widely witnessed in the post-GFC context, in order to stimulate domestic economic expansion and overcome a slow pace of economic growth. Since the parameter β_j for all US-REIT sub-sectors was considerably larger than the values for α_j, the long memory of US-REIT sub-sectors has been validated.

Overall, the sub-period analysis substantiates that different property types of US-REITs were more significant portfolio enhancers than diversified US-REITs over two sub-periods. Specifically, sector-specific US-REITs registered higher portfolio returns and reduced larger portfolio risk level compared with diversified US-REITs. An overall picture from interest rate sensitivity analysis shows time-varying interest rate sensitivity of US-REIT sub-sectors. Retail, residential and diversified REITs were more susceptible to interest rate changes over two sub-periods, while office REITs was unaffected by both 3-month and 10-year interest rates over two sub-periods. This shows that sector-specific REITs were less sensitive to the interest rate risk than diversified REITs over the two sub-periods, particularly in the post-GFC investment context. More importantly, this highlights the existence of REIT specialisation value in the USA over the pre-GFC and post-GFC contexts.

Table 9-13: Sub-period GARCH-M model for US sector-specific REITs

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel A: Diversified				
Mean equation				
Const	−6.309(−1.560)	−6.163(−1.666)***	0.063(0.757)	−0.119(−1.011)
Garch term	0.001(0.008)	0.044(0.438)	−0.014(−0.270)	−0.025(−0.495)
Market	1.210(8.804)***	1.233(9.616)***	0.991(45.435)***	0.995(45.679)***
IR	1.293(1.589)	1.328(1.691)*	−0.033(−0.874)	0.074(1.972)**
Variance equation				
Const	0.191(1.473)	0.211(1.528)	0.692(4.761)***	0.692(4.884)***
Arch	0.212(1.892)*	0.234(1.904)*	0.151(4.315)***	0.157(4.439)***
Garch	0.700(5.947)***	0.667(5.230)***	0.431(4.193)***	0.424(4.193)***
Market Vol	−0.469(−1.666)*	−0.414(−1.563)	0.002(0.073)	0.020(0.689)
IR Vol	0.234(0.675)	−0.167(−0.209)	−170.435(−1.531)	−16.744(−0.916)
Panel B: Office				
Mean equation				
Const	−3.521(−0.956)	−2.585(−0.731)	0.013(0.298)	−0.067(−0.934)
Garch term	−0.443(−1.529)	0.172(0.405)	0.023(0.391)	−0.009(−0.131)
Market	1.163(12.372)***	1.125(11.423)***	0.907(54.625)***	0.907(54.639)***
IR	0.799(1.113)	0.522(0.712)	0.008(0.285)	0.042(1.423)
Variance equation				
Const	0.023(1.768)*	0.085(1.058)	0.008(2.267)**	0.009(2.276)**
Arch	0.002(1.492)	0.029(0.801)	0.023(4.224)***	0.023(4.210)***
Garch	0.994(89.269)***	0.893(9.316)***	0.965(91.301)***	0.965(90.550)***
Market Vol	−0.251(−0.965)	−0.206(−0.804)	0.009(0.409)	0.019(0.799)
IR Vol	−0.246(−0.946)	−0.089(−0.120)	−109.331(−1.436)	−10.420(−0.695)

Table 9-14: Sub-period GARCH-M model for US sector-specific REITs (Cont1)

	Pre-GFC: July 2006–September 2007		Post-GFC: September 2009–December 2018	
	3M	10Y	3M	10Y
Panel C: Retail				
Mean equation				
Const	−6.435(−5.479)***	−5.681(−2.510)**	0.066(1.016)	−0.031(−0.337)
Garch term	0.602(1.321)	−1.247(−1.071)	−0.066(−1.014)	−0.094(−1.471)
Market	0.906(20.917)***	0.915(13.323)***	0.662(34.615)***	0.663(34.658)***
IR	1.313(5.614)***	1.191(2.512)**	0.037(1.152)	0.053(1.676)*
Variance equation				
Const	0.417(1.997)**	0.626(1.877)*	0.164(3.358)***	0.163(3.370)***
Arch	0.106(1.165)	0.049(1.128)	0.099(4.304)***	0.099(4.325)***
Garch	0.463(1.972)**	0.404(1.492)	0.751(12.758)***	0.752(12.874)***
Market Vol	−0.420(−6.241)***	−0.150(−0.767)	0.043(1.960)**	0.057(2.230)**
IR Vol	5.025(2.039)**	−3.003(−1.070)	−165.455(−1.572)	−12.578(−0.815)
Panel D: Industrial				
Mean equation				
Const	−9.651(−2.800)***	−4.724(−1.313)	−0.021(−0.025)	0.005(0.011)
Garch term	0.312(0.642)	0.575(1.389)	0.117(0.022)	0.100(0.034)
Market	1.050(7.897)***	1.046(9.520)***	0.882(45.812)***	0.882(46.109)***
IR	1.974(2.887)***	1.054(1.395)	0.037(0.973)	−0.016(−0.393)
Variance equation				
Const	0.092(0.75)	0.035(1.022)	0.901(0.550)	0.069(2.876)***
Arch	0.004(1.046)	0.038(1.149)	0.002(4.145)***	0.002(4.021)***
Garch	0.850(4.858)***	0.922(14.673)***	0.942(47.002)***	0.942(46.613)***
Market Vol	−0.485(−1.793)*	−0.239(−0.924)	0.025(1.047)	0.025(0.857)
IR Vol	−1.836(−0.457)	0.271(0.317)	−166.958(−1.493)	0.619(0.030)

Table 9-15: Sub-period GARCH-M model for US sector-specific REITs (Cont2)

	Pre-GFC: July 2006–September 2007		**Post-GFC: September 2009–December 2018**	
	3M	10Y	3M	10Y
Panel E: Residential				
Mean equation				
Const	−3.359(−0.718)	−6.271(−1.862)*	−0.002(−0.051)	−0.262(−2.991)***
Garch term	0.337(0.772)	0.695(1.849)*	0.072(1.631)	0.035(0.760)
Market	1.048(9.116)***	1.020(9.671)***	0.743(36.565)***	0.747(36.537)***
IR	0.649(0.728)	1.384(1.943)*	0.037(1.163)	0.125(3.660)***
Variance equation				
Const	0.024(0.707)	0.018(0.682)	0.013(2.607)***	0.011(2.378)**
Arch	0.051(1.477)	0.050(1.882)*	0.031(4.930)***	0.033(4.110)***
Garch	0.932(15.472)***	0.938(22.104)***	0.957(90.741)***	0.958(97.036)***
Market Vol	−0.475(−2.050)**	−0.304(−1.346)	0.016(0.594)	0.034(1.138)
IR Vol	0.345(1.496)	0.001(0.008)	−275.246(−2.992)***	−24.063(−1.290)
Panel F: Specialty				
Mean equation				
Const	−3.277(−1.311)	−1.528(−0.735)	0.050(0.978)	−0.036(−0.390)
Garch term	−0.279(−0.983)	−0.200(−1.281)	−0.022(−0.515)	−0.042(−1.037)
Market	1.099(17.626)***	0.909(11.876)***	0.676(31.132)***	0.675(31.059)***
IR	0.731(1.489)	0.391(0.913)	−0.015(−0.369)	0.036(1.059)
Variance equation				
Const	0.286(1.401)	0.451(1.787)*	0.023(2.380)**	0.023(2.378)**
Arch	0.116(0.992)	0.274(1.344)	0.045(4.180)***	0.045(4.175)***
Garch	0.597(2.359)**	0.324(1.066)	0.940(64.217)***	0.940(64.199)***
Market Vol	−0.370(−2.154)**	−0.299(−1.341)	0.050(1.801)*	0.058(1.830)*
IR Vol	0.063(0.234)	−0.557(−0.779)	−97.881(−0.919)	−3.372(−0.188)

9.8 SUMMARY OF FINDINGS

This chapter aimed to validate REIT specialisation value in the USA by investigating the performance of all US-REIT sub-sectors (diversified, office, retail, industrial, residential and specialty REITs) in domestic mixed-asset portfolios in the USA. The statistical analyses comprise the risk-adjusted performance, portfolio diversification benefits, risk-adjusted performance comparisons, roles in mixed-asset portfolios, the interest rate sensitivity and sub-period analysis from July 2006 to December 2018. The risk-adjusted performance and portfolio analysis were measured by monthly total returns of REIT sub-sectors, stocks and bonds in the USA. The interest rate sensitivity analysis was undertaken by daily total returns of REIT sub-sectors in the USA. The primary empirical results are as follows.

9.8.1 Risk-adjusted Performance

Table 9-14 summarises the performance of sector-specific US-REITs from July 2006 to December 2018, as well as the pre-GFC (Panel B) and post-GFC timeframes (Panel C). As seen in Panel A, different property types of REITs offered superior average annual returns compared with diversified REITs and bonds in the USA over the full sample period. The only exception was industrial REITs, providing the lowest average annual returns of all assets in the US context. Meanwhile, most sector-specific US-REITs were outperformed by stocks, which was the third-best performer in terms of average annual returns. Residential and specialty US-REITs registered higher average annual returns than stocks in the USA. In terms of risk level, most sector-specific US-REITs were less volatile than diversified US-REITs, including office, residential and specialty US-REITs. Retail and industrial US-REITs were riskier than diversified US-REITs. All property types of US-REITs offered a higher level of annual risk than either stocks or bonds in the USA. On a risk-adjusted return basis, all property types of US-REITs except for industrial US-REITs outperformed diversified US-REITs. Apart from specialty and residential US-REITs, most sector-specific US-REITs were inferior to both stocks and bonds. As displayed in Panel B and C, the sub-period analysis supports the findings from the full period results, including that different property types of REITs outperformed diversified REITs in the US investment context, particularly in the post-GFC context. Specifically, different property types of US-REITs were inferior to stocks but superior to bonds in the

USA on a risk-adjusted return basis over each sub-period. Similar results regarding the stronger performance of different property types of REITs compared with diversified REITs were found in the Japan, Australia and Singapore investment contexts over the study period.

While the previous results have shown that different property types of REITs offered stronger risk-adjusted returns than diversified REITs in the USA over the study period, it is still unclear whether sector-specific REITs are statistically and significantly different from diversified REITs on a risk-adjusted return basis. The results of the pairwise test are depicted in **Table 9-15**. Most sector-specific REITs are statistically significant at the 1% level over the entire sample period. This implies there were significant disparities in the Sharpe ratio between each property type of REITs and diversified REITs in the USA. The only exception is office REITs.

In brief, different property types of REITs were generally superior risk-adjusted performers to diversified REITs and bonds in the USA from July 2006 to December 2018, particularly in the post-GFC context. However, they were inferior to stocks in the USA over the full study period. In the US context, sector-specific REITs were generally a distinct investment asset from diversified REITs on a risk-adjusted performance basis. The US results are generally consistent with the Japan, Australian and Singapore results, the only exception being the distinction between office and diversified REITs in the USA. This implies that office REITs behaved similarly to diversified REITs on a risk-adjusted return basis in the USA. This is evident from the high correlation between office and diversified REITs ($r = 0.93$). This may be attributed to the fact that diversified US-REITs included a higher proportion of office properties in their property portfolios over the study period, such as Vornado Realty Trust (36.7% office properties) and W. P. Carey (22.6%) (Vornado Realty Trust, 2018, W. P. Carey, 2018).

Table 9-16: Sector-specific US-REIT performance summary: domestic

Did sector-specific REITs offer better performance compared with domestic asset classes?				
	Asset	Return	Risk	Risk-adjusted return
Panel A: Whole period				
Office	1	✔	✔	✔
	2	✘	✘	✘
	3	✔	✘	✘
Retail	1	✔	✘	✔
	2	✘	✘	✘
	3	✔	✘	✘
Industrial	1	✘	✘	✘
	2	✘	✘	✘
	3	✘	✘	✘
Residential	1	✔	✔	✔
	2	✔	✘	✘
	3	✔	✘	✔
Specialty	1	✔	✔	✔
	2	✘	✘	✘
	3	✔	✘	✔
Panel B: Pre-GFC				
Office	1	✘	✘	✘
	2	✘	✘	✘
	3	✔	✘	✔
Retail	1	✔	✘	✔
	2	✘	✘	✘
	3	✔	✘	✔
Industrial	1	✔	✘	✔
	2	✘	✘	✘
	3	✔	✘	✔
Residential	1	✘	✘	✘
	2	✘	✘	✘
	3	✘	✘	✔
Specialty	1	✔	✘	✔
	2	✘	✘	✘
	3	✔	✘	✔
Panel C: Post-GFC				
Office	1	✔	✘	✔
	2	✘	✘	✘
	3	✔	✘	✔
Retail	1	✔	✘	✔
	2	✔	✘	✘
	3	✔	✘	✔
Industrial	1	✔	✘	✔
	2	✔	✘	✘
	3	✔	✘	✔
Residential	1	✔	✘	✔
	2	✔	✘	✘
	3	✔	✘	✔
Specialty	1	✔	✔	✔
	2	✘	✘	✘
	3	✔	✘	✔

Note: 1 = diversified REITs, 2 = stocks, 3 = bonds

Table 9-17: Risk-adjusted performance comparison summary for sector-specific and diversified US-REIT: domestic

	1	2	3	4	5
Diversified	✕	✔*	✔*	✔*	✔*

Note: 1 = office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty REITs
* = significant at 1% level

9.8.2 Portfolio Diversification Benefits

Table 9-16 and **Figure 9-11** report portfolio diversification benefits of different property types of US-REITs, diversified REITs with the mainstream asset classes in the USA over the entire study period, including two sub-periods. Most sector-specific US-REITs presented greater diversification benefits with both stocks and bonds than did their diversified counterparts over the full sample period. However, specialty and office US-REITs offered lesser diversification benefits with stocks compared with diversified US-REITs.

The sub-period results are generally consistent with the full period results. Prior to the GFC, industrial and retail US-REITs were superior to diversified US-REITs in terms of portfolio diversification benefits with stocks, while specialty and office US-REITs were better than diversified US-REITs in terms of portfolio diversification benefits with bonds. Post to the GFC, residential and retail US-REITs presented stronger diversification benefits with stocks than did diversified REITs, while industrial, specialty and office US-REITs surpassed diversified US-REITs in terms of portfolio diversification benefits with bonds. In terms of an inter-property investment strategy, a sectoral US-REIT (average $r = 0.84$) investment strategy offered greater portfolio diversification benefits than an inter-REIT (average $r = 0.88$) investment strategy over the entire sample period.

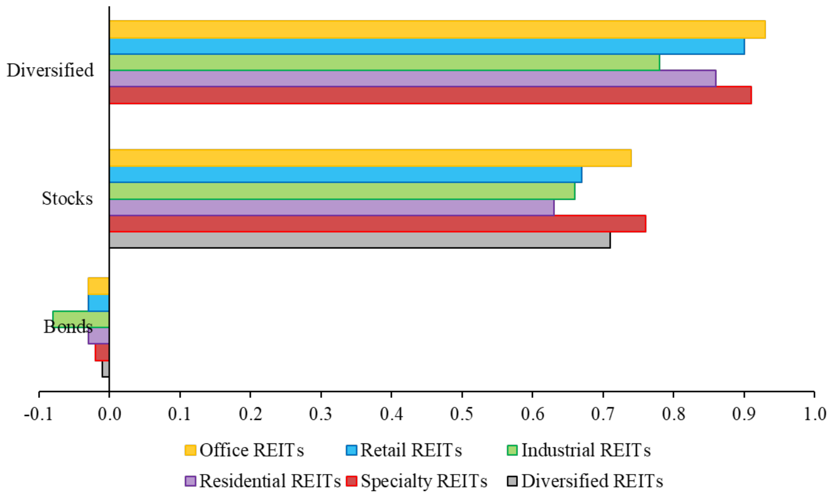
In short, these findings indicate that different property types of REITs generally presented stronger diversification benefits with both stocks and bonds compared with diversified REITs in the USA from July 2006 to December 2018. In addition, the results highlight that a sectoral REIT investment strategy could provide greater portfolio diversification benefits for property investors seeking portfolio diversifications in the USA than an inter-REIT investment strategy. This is due to that a diversified REIT portfolio comprises a property portfolio covering different types of property sectors. These findings validate the existence of REIT specialisation value in the USA over the last 12 years. These also imply that institutional investors should actively control their own sectoral portfolio diversifications, rather than passively relying on a diversified portfolio in the USA. Furthermore, time-varying portfolio diversifications of sector-specific REITs implies the dynamic investment performance of sector-specific REITs in the USA.

Table 9-18: Sector-specific US-REIT correlation matrix summary

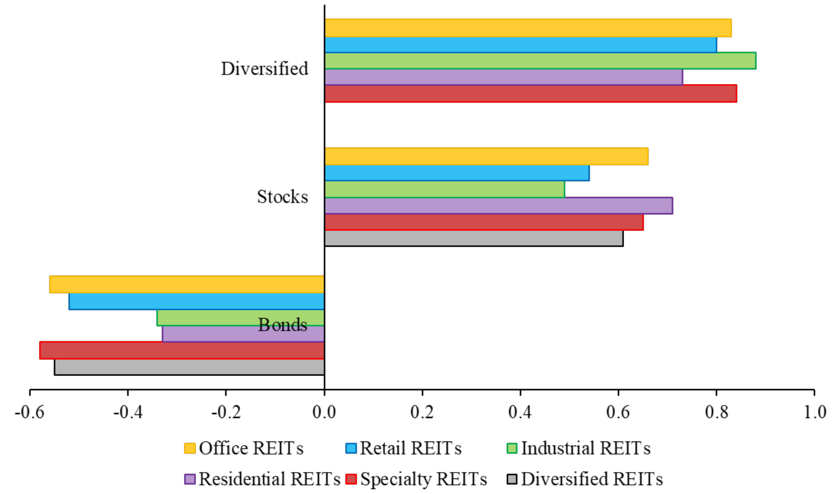
	Office	Retail	Industrial	Residential	Specialty	Diversified
Panel A: Whole period						
Diversified	0.93	0.90	0.78	0.86	0.91	1.00
Stocks	0.74	0.67	0.66	0.63	0.76	0.71
Bonds	−0.03	−0.03	−0.08	−0.03	−0.02	−0.01
Panel B: Pre-GFC						
Diversified	0.83	0.80	0.88	0.73	0.84	1.00
Stocks	0.66	0.54	0.49	0.71	0.65	0.61
Bonds	−0.56	−0.52	−0.34	−0.33	−0.58	−0.55
Panel C: Post-GFC						
Diversified	0.93	0.86	0.80	0.83	0.89	1.00
Stocks	0.68	0.57	0.70	0.48	0.69	0.67
Bonds	0.18	0.23	0.09	0.24	0.14	0.19

Figure 9-11: Sector-specific US-REIT correlation summary: sector-specific REITs vs diversified REITs vs stocks

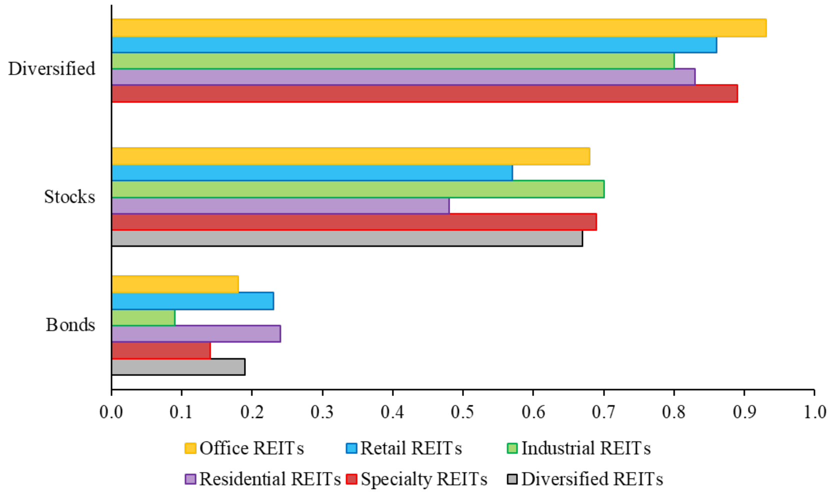
Panel A: Whole period



Panel B: Pre-GFC



Panel C: Post-GFC



9.8.3 Role in Mixed-asset Portfolios

Given stronger average annual returns, lower risk levels and low correlations with both stocks and bonds, different property types of REITs played a more significant role than diversified REITs in domestic mixed-asset portfolios in the USA over the full study period, including two sub-periods. Compared with the mainstream asset classes, sector-specific REITs represented a lower lesser portfolio share over the entire study period, particularly before the GFC. However, the resurgence in sector-specific REIT markets in the post-GFC context powered sector-specific REITs as the pre-eminent contributor across the whole risk-return band of the post-GFC mixed-asset portfolio in the USA. Most portfolio allocations of different property types of REITs were found in the higher end of the risk-return range. On the other hand, diversified REITs found no place in the US mixed-asset portfolio over the full sample period, including two sub-periods, as reported in **Table 9-17**.

In brief, the US portfolio analyses imply that sector-specific REITs are an added-value and strategic portfolio asset for both risk-averse and risk-taking investors, since their portfolio configurations were embedded across the entire risk-return band. In addition, the results validate the presence of REIT specialisation value in the USA, evident from the stronger role of different property types of REITs in the US mixed-asset portfolios compared with their diversified counterparts over the last 12 years, particularly in the post-GFC context. This market phenomenon has also been witnessed in domestic mixed-asset portfolios across various domestic jurisdictions in the Asia-Pacific, namely Japan, Australia and Singapore.

Table 9-19: Sector-specific US-REIT asset allocation summary: domestic

	Sector-specific REITs	Diversified REITs	Stocks	Bonds
Panel A: Whole period				
	31.8%	0.0%	46.4%	21.8%
Panel B: Pre-GFC				
	0.2%	0.1%	55.5%	44.2%
Panel C: Post-GFC				
	42.0%	0.0%	30.8%	27.2%

9.8.4 Interest Rate Sensitivity

Using daily excess returns for six REIT sub-sector indices (diversified, office, retail, industrial, residential and specialty REITs) in the US context from 19 July 2006 to 31 December 2018, the short- and long-term interest rate sensitivity of sector-specific US-REITs were measured using the GARCH-M specification framework. **Table 9-18** summarises the primary interest rate sensitivity results. During the full study period (Panel A), diversified REITs was the most susceptible REIT sub-sector to interest rate movements. Specifically, diversified REIT excess returns were affected by changes in the volatility of 3-month interest rates and the level of 10-year interest rates. Meanwhile, industrial REITs was seen to be vulnerable to fluctuations in the level of both the 3-month and 10-year interest rate series. Compared with diversified and industrial REITs, retail REITs was sensitive to movements in the 3-month interest rate level, while residential and specialty REITs were susceptible to changes in the level and volatility of 10-year interest rate respectively. On the other hand, office REITs was immune to interest rate changes over the full sample period.

The full period results are consistent with the post-GFC results (Panel C) but different from the pre-GFC results (Panel B). Prior to the GFC, retail REITs was documented to be the most vulnerable REIT sub-sector to interest rate fluctuations. It was found to be sensitive to the level and volatility of 3-month interest rates and the 10-year interest rate level. However, office and specialty REITs were unaffected by interest rate changes. At the same time, industrial REITs was sensitive to changes in the 3-month interest rate level, while residential and diversified REITs were influenced by movements in the 10-year interest rate level. Post to the GFC, office, industrial and specialty REITs were reported to be immune to both the short- and long-term interest rate changes. On the other hand, diversified, retail and residential REITs were sensitive to movement in the long-term interest rate level. The lack of significance of the interest rate level and volatility effects on excess returns for office REITs in the USA may suggest that the US office REIT market was less sensitive to the interest rate risk compared with the other sector-specific and diversified REITs. Industrial and specialty REITs are advised for international REIT investors seeking to build and manage a US portfolio in order to reduce or mitigate the interest rate risk in the post-GFC context.

In sum, sector-specific REITs were less sensitive to interest rate changes than diversified REITs, particularly office REITs over the full study period and industrial and specialty REITs in the post-GFC context. This may be attributed to the fact that a diversified portfolio comprises different types of property sectors. This market phenomenon has also been seen in the Asia-Pacific REIT markets. Of sector-specific REITs, retail and residential REITs were more vulnerable to interest rate movements. This may be attributed to the distinct lease structures of each property sector, as the term structure of property leases can be substantially impacted by the interest rate risk (Crosby *et al*., 2003; Ambrose and Yildirim, 2008; Agarwal *et al*., 2011). Specifically, retail property leasing typically includes percentage rent (Crosby *et al*., 2003), while residential property leasing is normally on a short-term basis (Miles and McCue, 1982). The high level of interest rate sensitivity of industrial REITs prior to the GFC may be attributed to the changing trajectory of I&L REITs, which largely replaced the traditional industrial property components with logistic properties in the post-GFC context in order to gain strategic exposure to recent e-commerce trends, as noted by Lin *et al*. (2020). These findings imply the existence of REIT specialisation value in the USA over the last 12 years.

Table 9-18: Sector-specific US-REIT interest rate sensitivity summary

Are Sector-specific US-REITs sensitive to movements in the level and volatility of short- and long-term interest rates?

	1	2	3	4	5	6
Panel A: Whole period						
IR3m	✕	✔	✔	✕	✕	✕
IR3m Vol.	✕	✕	✕	✕	✕	✔
IR10y	✕	✕	✔	✔	✕	✔
IR10y Vol.	✕	✕	✕	✕	✔	✕
Panel B: Pre-GFC						
IR3m	✕	✔	✔	✕	✕	✕
IR3m Vol.	✕	✔	✕	✕	✕	✕
IR10y	✕	✔	✕	✔	✕	✔
IR10y Vol.	✕	✕	✕	✕	✕	✕
Panel C: Post-GFC						
IR3m	✕	✕	✕	✕	✕	✕
IR3m Vol.	✕	✕	✕	✕	✕	✕
IR10y	✕	✔	✕	✔	✕	✔
IR10y Vol.	✕	✕	✕	✕	✕	✕

Note: 1 = Office, 2 = retail, 3 = industrial, 4 = residential, 5 = specialty, 6 = diversified

9.9 SUMMARY OF CHAPTER

Overall, this chapter has corroborated the stronger risk-adjusted performance, lower correlation with both stocks and bonds, stronger roles in domestic mixed-asset portfolios and lower sensitivity to interest rate changes of different property types of REITs compared with diversified REITs in the USA from July 2006 to December 2018. A stronger sectoral REIT diversification strategy has been reported in the US context compared with an inter-REIT investment strategy. This is particularly important for international REIT investors seeking listed property exposure in the USA, since the findings imply that institutional investors should actively make their own sectoral portfolio diversification decisions by investing in different property types of US-REITs, rather than relying on a diversified REIT portfolio with multiple property sectors. More importantly, the existence of REIT specialisation value in the USA has been validated in this chapter, underpinning the assertion of REIT specialisation value in the Asia-Pacific region and the US contexts over the last 12 years, including two sub-periods.

The next chapter summarises the research findings of this thesis, highlighting the practical investment implications of different property types of REITs in the Asia-Pacific region and the USA over the study period. Additionally, the limitations of the research and future research recommendations will be discussed.

CHAPTER 10
CONCLUSIONS

Chapter 10 illustrates the conclusions and property investment implications of this research. In addition, this chapter elucidates the overall contributions of this research, and explores the research limitations and potential future research directions.

10.1 INTRODUCTION

Asia-Pacific REITs are a well-established listed property investment channel in the Asia-Pacific and international property investment space. In the international REIT investment context, Asia-Pacific REITs have become an increasingly significant contributor by market capitalisation and numbers of REIT equities. The significance of the Asia-Pacific REIT markets can be elucidated by the fact that REITs have been seen as similar to investment in stocks, and have been expected to reflect the investment performance of direct property in the long term, with added benefits of greater liquidity, higher transparency, substantial and stable dividend yields, lower transaction costs, reduced performance and cost management structures, and strong portfolio diversification benefits, as well as the existence of the public markets. Hence, REITs have been validated as a close substitute for direct property in multi-asset portfolios by international scholars.

One of the prevailing attributes of Asia-Pacific REITs is that sector-specific REITs – such as Japan Real Estate Investment (Japan; office sector; US$7.8B), Vicinity Centres (Australia; retail sector; US$7.0B), GLP J-REIT (Japan; industrial sector; US$3.9B), and Keppel DC REIT (Singapore; specialty sector; US$1.3 B) – play a primary role in the Asia-Pacific REIT markets compared with diversified REITs such as Orix JREIT (Japan; US$4.6B) and Mapletree North Asia Commercial Trust (Singapore; US$2.6B). On average, the percentage of sector-specific REITs to composite REITs was 75.2% in Japan, 74.1% in Australia and 91.9% in Singapore over the last 12 years. This market phenomenon has also been witnessed in the international REIT context, including in the USA (93%) and Europe (72%). This has made clear that sector-specific REITs play a prevailing role in the Asia-Pacific REIT markets compared with diversified REITs.

Therefore, this study aimed to investigate the risk-return characteristics of Asia-Pacific sector-specific REITs by assessing their risk-adjusted returns, portfolio diversification benefits, risk-adjusted performance comparisons, roles in mixed-asset portfolios at domestic, regional and international levels, and interest rate. In addition, this study assessed the portfolio returns, risk, geographic and sectoral diversifications, and asset allocations of different property types of regional REIT-based portfolios in the Asia-Pacific for the first time. Six research questions concerning Asia-Pacific sector-specific REITs were addressed in this study.

RQ1. Do sector-specific REITs outperform diversified REITs in the Asia-Pacific region?

RQ2. What roles do Asia-Pacific sector-specific REITs play in domestic mixed-asset portfolios compared with diversified REITs, stocks and bonds?

RQ3. What are the optimum levels of Asia-Pacific-based sector-specific REITs in mixed-asset portfolios in both the regional and international contexts?

RQ4. What are portfolio returns, risk, diversifications, and asset allocation implications of different property types of Asia-Pacific REIT-based portfolios?

RQ5. Would Asia-Pacific sector-specific REITs response to changes in interest rates divergently?

RQ6. Would the REIT specialisation value in the Asia-Pacific exist in other REIT markets?

This chapter offers a brief overview of the key findings of the thesis by synthesising the primary findings presented in the preceding chapters. The theoretical and practical investment implications of this study are also highlighted, as well as the study limitations and recommendations for future research.

10.2 MAIN FINDINGS

To answer the six research questions, the empirical results have been discussed and analysed in the five main analysis chapters, including Chapter 5: the significance and performance of Asia-Pacific sector-specific REITs in domestic mixed-asset portfolios (RQ1 and RQ2); Chapter 6: the significance and performance of different property types of Asia-Pacific REITs in regional and international mixed-asset portfolios (RQ3); Chapter

7: the significance and performance of different property types of Asia-Pacific REIT-based portfolios (RQ4); and Chapter 8: the interest rate sensitivity of Asia-Pacific sector-specific REITs (RQ5). Furthermore, the empirical results of these four chapters have been validated with the US-REIT market in Chapter 9 (RQ6).

10.2.1 Risk-adjusted Performance of Asia-Pacific Sector-specific REITs

10.2.1.1 Domestic Investment Context

The results highlight stronger risk-adjusted returns offered by sector-specific REITs compared with diversified REITs across Japan, Australia, Singapore and the USA over the full study period, including the pre-GFC and post-GFC timeframes. Different property types of REITs were generally validated as distinct investment assets from diversified REITs across these four markets over the entire period. Compared with the mainstream asset classes (stocks and bonds), superior risk-adjusted returns for different property types of REITs were generally observed in these four markets over the entire study timeframe. However, sector-specific REITs were inferior to stocks in Australia and the USA, and sector-specific S-REITs underperformed bonds in Singapore. Within the sub-periods, stronger risk-adjusted returns for sector-specific REITs compared with stocks were only observed in the Asia-Pacific region after the GFC. Sector-specific REITs were inferior to stocks in the Asia-Pacific region and the USA before the GFC.

In brief, the risk-adjusted performance analysis validated stronger risk-adjusted returns of different property types of REITs compared with their diversified counterparts across Japan, Australia, Singapore and the USA. This can be elucidated by the fact that sector-specific REITs generally offered higher average annual returns but lower risk levels than diversified REITs in these jurisdictions. The results are consistent with the findings of Lin *et al*. (2019a, b, 2020). These findings demonstrate the distinctive investment qualities of REITs among different types of property sectors and across various domestic jurisdictions. They also show that risk-return profiles of sector-specific REITs were different from the mainstream asset classes across these four jurisdictions. Additionally, the resurgence in the industrial REIT market in the post-GFC is in line with the findings of Lin *et al*. (2020), in which I&L US-REITs was highlighted. More importantly, these domestic findings confirm the existence of REIT specialisation value in the Asia-Pacific region and the USA from July 2006 to December 2018. The Australian REIT results are consistent with the findings of Lin *et al*. (2019a), which validated REIT specialisation value in Australia since January 2000.

10.2.1.2 Regional Investment Context

Within the regional context, most regional sector-specific REITs outperformed regional diversified REITs on a risk-adjusted return basis over the entire sample period, except for regional residential REITs. This is owing to the fact that regional sector-specific REITs offered higher average annual returns than regional diversified REITs. However, regional sector-specific REITs were more volatile than regional stocks over the entire study period. Regional specialty and industrial REITs were the only two REIT sub-sectors outperforming regional stocks on a risk-adjusted return basis. The full period results are consistent with the sub-period outcomes. The exceptions are regional office and residential REITs before the GFC, and regional residential REITs after the GFC.

Briefly, these findings highlight the existence of REIT specialisation value in the Asia-Pacific at the aggregate regional level from July 2006 to December 2018. During the full study period, the regional industrial and specialty REIT markets stood out and offered higher annual returns and lower annual risk levels compared with other REIT sub-sector markets. The stronger investment performance of the regional industrial REIT markets can be elucidated by the findings of Lin *et al*. (2020), namely, that Pacific Rim-based I&L REITs have often replaced the traditional industrial properties with logistic properties to gain strategic exposure to recent e-commerce trends in the post-GFC context.

10.2.1.3 International Investment Context

Within the global context, regional sector-specific REITs generally outperformed global stocks and US- and EU-REITs on a risk-adjusted return basis over the entire sample period, particularly for regional industrial and specialty REITs. Meanwhile, regional sector-specific REITs were riskier than global stocks and the US REITs. The full period results were reinforced by the pre-GFC findings, but differed slightly from the post-GFC outcomes. Post to the GFC, regional sector-specific REITs were inferior to global stocks and US-REITs on a risk-adjusted return basis, because of their higher risk levels.

The existence of REIT specialisation value has been reinforced by regional and global investment contexts at the aggregate regional level from July 2006 to December 2018. There are some interesting findings in the global context. The regional industrial and specialty REIT markets offered higher risk-adjusted returns than global stocks and US- and EU-REITs over the full study period. The regional residential REIT market was the worst risk-adjusted performer among all assets in the global context.

10.2.2 Portfolio Diversification Benefits of Asia-Pacific Sector-specific REITs

10.2.2.1 Domestic Investment Context

In terms of portfolio diversification potential, the results show that different property types of REITs presented stronger diversification benefits with stocks, and comparable diversification benefits with bonds, than their diversified counterparts in these four domestic jurisdictions over the full study period, including two sub-periods. In terms of an inter-property investment strategy, a sectoral REIT investment strategy offered larger portfolio diversification benefits than an inter-REIT investment strategy for REIT investors seeking portfolio diversifications across Japan, Australia, Singapore and the USA. This can be clarified by the fact that a diversified REIT portfolio comprises multiple property sectors. Time-varying portfolio diversification benefits of sector-specific REITs have been observed in various domestic jurisdictions during two sub-periods, as well as both a sectoral REIT investment strategy and an inter-REIT diversification strategy.

In short, different property types of REITs were validated as a more effective portfolio diversifier for portfolios containing stocks and bonds in the Asia-Pacific region and the USA, compared with their diversified counterparts. The results are in line with the findings of Lin *et al*. (2019a), in which sector-specific REITs were advised to be a preferable REIT structure for international REIT investors seeking portfolio diversifying exposure in Australia. More importantly, the diversity of sector-specific REITs can translate directly into improved sectoral diversifications for investors who employ a sectoral REIT investment strategy across these four domestic markets.

10.2.2.2 Regional Investment Context

In the regional context, the findings show that regional sector-specific REITs offered 2%

more diversification benefits with regional stocks than did their diversified counterparts over the entire study period. In particular, investors could receive better portfolio diversification benefits by adding regional industrial REITs and stocks. In terms of an inter-property investment strategy, a regional sectoral REIT investment strategy could deliver 6% more diversification benefits for property investors seeking portfolio diversifications in the Asia-Pacific, compared with a regional inter-REIT investment strategy. Time-varying results have been witnessed. Prior to the GFC, regional sector-specific REITs delivered 19% greater diversification benefits with regional stocks than did regional diversified REITs. A regional sectoral REIT investment strategy could offer 22% more diversification benefits for property investors compared with a regional inter-REIT investment strategy. Post to the GFC, regional industrial REITs was the only regional sector-specific REITs providing stronger diversification benefits with regional stocks than regional diversified REITs. The other regional sector-specific REITs were inferior to their diversified counterparts. At the same time, a regional sectoral REIT investment strategy could offer 4% greater diversification benefits for property investors compared with a regional inter-REIT investment strategy.

In short, a regional sectoral REIT investment strategy offered higher portfolio diversification benefits than a regional inter-REIT investment strategy. This confirms that sector-specific REITs were a more effective portfolio diversifier for international REIT investors seeking portfolio diversifications in the region compared with their diversified counterparts. This suggests that REIT investors seeking portfolio diversifications should actively make their own sectoral diversification decisions, rather than passively selecting a diversified REIT portfolio with multiple property sectors in the region. It also confirms that a regional sectoral REIT investment strategy offered improved sectoral diversifications for investors, owing to the diversity of different property types of REITs in the Asia-Pacific region.

10.2.2.3 International Investment Context

In the global context, different property types of regional REITs delivered stronger diversification benefits with global stocks than did their diversified counterparts over the entire sample period, including two sub-periods. On average, regional sector-specific REITs offered 4% more diversification benefits with global stocks than did regional diversified REITs over the full sample period, 28% prior to the GFC, and 4% post-GFC. In terms of cross-continental inter-REIT portfolio diversification potential, international investors could gain stronger diversification benefits by investing in different property types of regional REITs than in regional diversified REITs. The superior diversification benefits with the US-REITs of regional sector-specific REITs compared to regional diversified REITs were 6% over the full study period, 28% prior to the GFC, and 11% post-GFC. On the other hand, regional sector-specific REITs' superiority to regional diversified REITs in terms of portfolio diversification benefits with EU-REITs was 2% over the full sample period, 13% prior to the GFC, and 6% post-GFC. A stronger geographic diversification strategy using regional sector-specific REITs could be optimally received by investors employing an Asia-Pacific-US or Asia-Pacific-Europe diversification approach from July 2006 to December 2018.

In summary, it is clear that international REIT investors seeking portfolio diversifying in the Asia-Pacific should actively make their own sectoral diversification decisions, rather than passively selecting a diversified REIT portfolio with multiple property sectors. This reinforces that a regional sectoral REIT investment strategy offered improved sectoral diversifications for investors, as well as attractive geographic diversifications with cross-continental REITs. This is despite that there were rising correlations between different property sectors of REITs and major asset classes across the sample markets. This may be attributed to the increasing financialisation of global REITs since the onset of the GFC (Buchanan, 2017; August and Walks, 2018, Coën *et al*., 2020; Nethercote, 2020). The rise of finance has resulted in over-leveraged and debt-fuelled property markets after the GFC (Christophers, 2013; Fernandez and Aalbers, 2016). Therefore, intensified linkages between REITs and finance sectors were reported by global property scholars (Hoesli and Moreno, 2006; Sing *et al*., 2016; Van Nieuwerburgh, 2019).

10.2.3 Role of Asia-Pacific Sector-specific REITs in Mixed-asset Portfolios

10.2.3.1 Domestic Investment Context

Sector-specific REITs were found to play a more significant role in domestic multi-asset portfolios across Japan, Australia, Singapore and the USA compared with diversified REITs from July 2006 to December 2018. In a three-asset portfolio with domestic financial assets, the inclusion of different property types of REITs offered greater returns than the inclusion of diversified REITs or financial asset-only portfolios (stocks and bonds) over the full sample period. Significant domestic portfolio allocations of sector-specific REITs were observed for Japan (57.9%), Australia (40.2%), Singapore (38.4%) and the USA (31.8%) over the entire study period. On the other hand, diversified REITs did not play any role in domestic mixed-asset portfolios in Japan, Australia and the USA, but had some presence in the Singapore mixed-asset portfolio. Compared with the local mainstream asset classes, different property types of REITs had a stronger role than both stocks and bonds across various domestic jurisdictions in the Asia-Pacific region. In the USA, stocks were slightly superior to sector-specific REITs. This reflects the stronger investment performance of local sector-specific REITs compared with diversified REITs, stocks and bonds across these four markets. These findings are consistent with the outcomes of Lin *et al*. (2019a, 2019b, 2020), in which optimal portfolio analysis was undertaken to assess the roles of different property types of REITs in domestic mixed-asset portfolios across Japan, Australia, Singapore and the USA.

Time-varying portfolio allocations of different property types of REITs were observed in all four domestic markets. Dominant portfolio compositions of sector-specific REITs were seen for Japan (60.6%), Australia (71.1%), Singapore (40.9%) and the USA (42.0%) in the post-GFC context. Meanwhile, diversified REITs did not have any role in domestic mixed-asset portfolios in Japan, Australia and the USA, but featured in the Singapore multi-asset portfolio. Before the GFC, smaller portfolio components of sector-specific REITs were witnessed for Japan (15.5%), Australia (12.4%), Singapore (33.9%) and the USA (0.2%) in domestic mixed-asset portfolios compared with stocks and bonds. Diversified REITs did not have any role in the entire portfolio compositions in various domestic jurisdictions. The post-GFC portfolio allocations of sector-specific REITs were enlarged in domestic mixed-asset portfolios compared with their pre-GFC levels.

In summary, the findings have several investment implications. Firstly, sector-specific REIT channels not only delivered significant increments in the efficient frontiers, but also allowed for a wider risk-return band compared with diversified REIT vehicles and financial asset-only portfolios. Secondly, sector-specific REITs were configured across the entire risk-return scale of mixed-asset portfolios, but showed stronger portfolio compositions in the higher end of the risk-return spectrum. This suggests sector-specific REITs as an important component for both risk-averse and risk-taking investors. This is particularly so for office REITs in Australia, industrial REITs in Japan and Singapore, and residential REITs in Japan and the USA. For conservative investors, retail REITs in Australia and Singapore, and specialty REITs in Australia, were seen as the appropriate REIT sub-sector forms. Thirdly, as a major portfolio component of different property types of REITs was observed in optimal domestic mixed-asset portfolios across these four markets, the accessibility to sector-specific REIT investment conduits could alter the dynamics of listed property allocations in domestic mixed-asset portfolios across these four markets. Fourthly, the results indicate that different property types of REITs were a good substitute for stocks in mixed-asset portfolios in various domestic jurisdictions over the study period, particularly in the post-GFC context. This is particularly the case for industrial REITs in Japan and Singapore, office REITs in Australia and residential REITs in the USA, which offered enhanced portfolio returns irrespective of investors' risk preferences. Importantly, the existence of REIT specialisation value was confirmed across Japan, Australia, Singapore and the USA from July 2006 to December 2018. The Australian REIT results are consistent with the findings of Lin *et al*. (2019a), with the existence of REIT specialisation value continuing in Australia since January 2000.

10.2.3.2 Regional Investment Context

Within the regional investment framework over the full sample period, a dominant portfolio allocation was allocated to regional sector-specific REITs (74.2%) across the full portfolio risk-return spectrum, particularly for regional specialty (48.4%) and industrial REITs (19.9%). However, diversified REITs did not play any role in the entire optimal portfolio composition. Similar portfolio compositions of regional sector-specific REITs were also observed during the two sub-periods. Regional sector-specific REITs increased their portfolio share in the post-GFC investment context compared with the pre-GFC performance (from 64.0% to 86.1%), while regional stocks significantly reduced in the optimal portfolio allocations (from 36.0% to 13.9%). Diversified REITs did not play any role in the portfolio allocations during the two sub-periods.

There are some investment implications for regional REIT investors. Firstly, the existence of REIT specialisation value has been confirmed in the Asia-Pacific at the aggregate regional level. Secondly, different property types of regional REITs were better substitutes for regional stocks than their diversified counterparts. Furthermore, regional sector-specific REITs are the most appropriate form of regional REIT sub-sector for both risk-averse or risk-taking investors, as they were embedded across the broad risk-return band. Specifically, regional specialty REITs was an added-value asset for investors constructing regional mixed-asset portfolios in the Asia-Pacific prior to the GFC, and regional office and industrial REITs were stronger candidates in regional multi-asset portfolios post to the GFC. These findings are generally consistent with the results of Lin *et al*. (2020), in which I&L REITs was found to enhance portfolio returns in mixed-asset portfolios across four domestic markets in the Pacific Rim region.

10.2.3.3 International Investment Context

Within the international investment framework, the full period results reveal a number of interesting findings. More than half of portfolio compositions were allocated to regional sector-specific REITs (66.3%) across the entire risk-return spectrum, with minor roles for global stocks (31.9%) and US-REITs (1.8%). This saw regional specialty REITs as the main contributor to the international mixed-asset portfolio. The full period results were supported by the sub-period outcomes. Regional sector-specific REITs maintained their prominent roles during the two sub-periods, while global stocks significantly decreased its portfolio compositions after the GFC (from 38.8% to 5.9%), and US-REITs broadened its portfolio allocations before the GFC (from 0.0% to 41.5%).

Some investment implications should be suggested to international REIT investors. Firstly, Asia-Pacific-based sector-specific REITs were shown to be a close substitute for global stocks in international mixed-asset portfolios. Secondly, despite the fact that the resurgence in the US-REIT market in the post-GFC context resulted in it being one of the main contributors to international portfolio allocations, regional office REITs played the prominent role in the total portfolio compositions. This confirms that Asia-Pacific sector-specific REITs were generally the most attractive REIT vehicle in the international REIT context for international REIT investors from July 2006 to December 2018. In particular, Asia-Pacific specialty REITs was an added-value asset for investors establishing international mixed-asset portfolios prior to the GFC, while Asia-Pacific office and industrial REITs were stronger contenders post to the GFC.

10.2.4 Different Property Types of Asia-Pacific REIT-based Portfolios

10.2.4.1 Risk-adjusted Performance of Cross-country Sector-specific REITs

In the regional office REIT context, Japan was the best risk-adjusted performer, having higher annual returns and lower annual risk than Australia, Singapore and the USA from July 2006 to December 2018. This is despite Singapore offering the highest annual returns. During the two sub-periods, Australia was the strongest risk-adjusted performer, followed by Singapore.

In the regional retail REIT context, Singapore offered higher risk-adjusted returns than the other retail REIT markets in the region over the full study period. Singapore was the best risk-adjusted performer before the GFC, while the USA was the best after the GFC.

In the regional industrial REIT context, Singapore was the best candidate, offering higher risk-adjusted returns than the other industrial REITs in the region over the full study period. However, during the two sub-periods, Australia replaced Singapore as the best risk-adjusted performer, followed by the USA and Singapore. The results are in line with the findings of Lin *et al*. (2020), in which a Pacific Rim I&L REIT-based portfolio was used as a robustness check, in order to reflect that institutional investors have a mandate to construct regional REIT-based portfolios from a practical point of view.

In the residential REIT context, the USA was the best investment destination, providing higher risk-adjusted returns than the other three markets over the full study period, particularly after the GFC. Prior to the GFC, Australia was the best risk-adjusted performer, despite being the worst risk-adjusted performer among all four markets over the entire study period, particularly in the post-GFC context.

In the specialty REIT context, Singapore was the best risk-adjusted performer over the full study period, particularly after the GFC. Before the GFC, Australia replaced Singapore as the best risk-adjusted performer. In short, these findings highlight risk-adjusted returns of different property types of REITs across Japan, Australia, Singapore and the USA from July 2006 to December 2018.

10.2.4.2 Geographic and Sectoral Diversification Benefits

Regarding the potential for cross-country portfolio diversifications, regional REIT investors could gain 23% more geographic diversification benefits by investing in a cross-country sectoral REIT investment strategy than from a cross-country inter-stock investment strategy from July 2006 to December 2018. A cross-country sectoral REIT investment strategy offered 8% more geographic diversification benefits than a cross-country inter-stock investment framework in the pre-GFC context, while it delivered 19% greater geographic diversification benefits than its inter-stock counterparts in the post-GFC context. Within a cross-country sectoral REIT investment strategy, a cross-country industrial REIT investment provided the best geographic diversification benefits for investors seeking geographic portfolio diversifications in the region over the full study period. It was followed by office, specialty, retail and residential REIT investment strategies. However, a cross-country residential REIT investment replaced its industrial REIT counterpart as the best geographic diversifier within the two sub-periods.

In terms of diversification approaches, the highest level of cross-country sectoral REIT diversifications could be optimally achieved by investors deploying a cross-country sectoral REIT investment strategy through a US-Japan diversification approach, followed by the routes of Japan-Australia, Japan-Singapore, US-Singapore, US-Australia and Australia-Singapore. The post-GFC results were consistent with the full period results. Nevertheless, a US-Japan diversification path was the worst before the GFC. These findings offer valuable geographic and sectoral diversification strategies for property investors seeking portfolio diversifications in the Asia-Pacific region and the USA.

10.2.4.3 Portfolio Allocations of Different Property Types of Regional REIT-based Portfolios

In the regional office REIT-based portfolio, a prominent portfolio allocation was given to Singapore (58.7%) across the whole portfolio risk-return spectrum from July 2006 to December 2018, due to its having highest annual returns of all office REIT markets in the region. At the same time, Japan (34.6%) was the second-best contributor to the optimal portfolio, with minor portfolio allocations for Australia (3.8%) and Singapore (2.9%) in the lower end of the risk-return range. Post to the GFC, Australia (75.7%) replaced

Singapore as the dominant option across the whole portfolio risk-return band, followed by Japan (16.8%), the USA (6.4%) and Singapore (1.0%), with their footprint in the lower end of the risk-return spectrum.

In the regional retail REIT-based portfolio, more than half of the portfolio compositions was allocated to Singapore (58.8%) across the broad risk-return spectrum over the full sample period, due to its having highest average annual returns of all retail REITs in the region. Australia (20.9%) and Japan (20.3%) were distributed in the lower-to-intermediate range of the portfolio risk-return scale, while the USA did not have any role in the entire portfolio. After the GFC, the USA (67.7%) replaced Singapore as the pre-eminent contributor across the whole portfolio risk-return band, complementing Singapore (23.2%) Japan (6.3%) and Australia (2.8%) when the risk level increased.

In the regional industrial REIT-based portfolio, more than 90% of the portfolio allocations were distributed to Singapore (90.1%) across the whole portfolio risk-return range over the entire study period, with negligible portfolio allocations to Australia (6.5%) and Japan (3.4%) configured in the lower end of the portfolio risk-return scale. Post to the GFC, the USA (68.7%) topped Singapore across the whole portfolio risk-return spectrum, overshadowing the portfolio allocations of Japan (17.1%), Australia (8.9%) and Singapore (5.3%) when the risk level heightened. The post-GFC results are consistent with the findings of Lin *et al*. (2020), in which I&L US-REITs was stronger than the other I&L REITs in the Pacific Rim region.

In the regional residential REIT-based portfolio, the USA recorded an average portfolio allocation of 72.2% over the full study period. Meanwhile, Singapore (18.6%) was found across the whole risk-return scale, while Japan (9.2%) was mostly embedded in the lower end of the risk-return range and Australia did not play any role. Post to the GFC, the USA (81.1%) maintained its first place, while Japan (14.0%) replaced Singapore as the second-best contributor to the optimal portfolio compositions. Australia (2.8%) and Singapore (2.1%) had minors role at the lower end of the risk-return spectrum.

In the regional specialty REIT-based portfolio, the dominant role of Singapore (70.5%) was witnessed across the entire risk-return band over the entire sample period. The USA (27.8%) showed a similar pattern but had a comparatively smaller role in the portfolio composition, while Japan (1.0%) and Australia (0.7%) were featured at the start of the portfolio risk-return scale. Post to the GFC, Australia (74.0%) was the most prominent contributor across the broad risk-return range. Japan (20.1%) showed its presence across the broad risk-return scale, and the USA (3.8%) and Singapore (2.1%) emerged at the start of the risk-return scale.

In short, these findings deliver a clear picture of the optimal portfolio construction for cross-country sector-specific REITs in different property types of regional REIT-based portfolios. This is particularly important for property investors constructing and managing portfolios with REITs in the Asia-Pacific region and the USA.

10.2.4.4 Portfolio Returns and Risk

During the full study period, the regional specialty REIT-based portfolio delivered the highest portfolio returns with the highest risk level among all property types of regional REIT-based portfolios, registering a portfolio return and risk at 12.6% p.a. and 23.1%, respectively. In terms of portfolio returns, it was followed by regional industrial (9.2% p.a.), residential (7.9% p.a.), retail (7.0% p.a.) and office REIT-based portfolios (6.1% p.a.). In contrast, the regional office REIT-based portfolio failed to offer increased portfolio returns but exposed investors to the second-highest level of portfolio volatility at 23.0%. The sub-period results were generally consistent with the full period outcomes. Prior to the GFC, the regional specialty REIT-based portfolio was the best risk-adjusted performer among five regional REIT-based portfolios, offering a portfolio return and risk of 86.3% p.a. and 23.5%, respectively. In terms of portfolio returns, it was followed by residential (55.9% p.a.), retail (49.1% p.a.), office (45.0% p.a.) and industrial REIT-based portfolios (39.1% p.a.). Conversely, the regional industrial REIT-based portfolio not only provided the lowest portfolio returns but also injected the highest portfolio risk of 19.7%. Post to the GFC, the regional specialty REIT-based portfolio maintained the first place on the risk-adjusted return ranking, registering a portfolio return and risk of 15.5% p.a. and 14.8%, respectively. On the portfolio return ranking, it was surpassed by residential (16.5% p.a.) and industrial REIT-based portfolios (15.5% p.a.) but exceeded retail (12.2% p.a.) and office REIT-based portfolios (12.0% p.a.). However, the regional office REIT-based portfolio was unable to offer enhanced portfolio returns but exposed investors to a high-risk level of 15.3%. This saw the renaissance of the regional industrial REIT-based portfolio in the post-GFC context. This may be attributed to the changing trajectory of I&L REITs, which have downsized traditional property components and enlarged logistics property allocations in order to cater to the strong e-commerce trend after the GFC, as noted by Lin *et al*. (2020).

Briefly, these empirical findings have valuable investment implications for international property investors, particularly REMFs/PSFs and international REIT investors, who construct and manage different property types of regional REIT-based portfolio in the Asia-Pacific region. For risk-taking investors, regional residential and industrial REIT-based portfolios offered higher portfolio returns but exposed investors to a higher level of portfolio risk in the post-GFC context. Meanwhile, conservative international property investors are advised to invest in the regional specialty REIT-based portfolios, with lower portfolio returns and risk level.

10.2.5 Interest Rate Sensitivity of Asia-Pacific Sector-specific REITs

The econometric analysis of the interest rate sensitivity of Asia-Pacific sector-specific REITs has yielded numerous interesting findings. An overall picture from these findings is that diversified REITs was generally more sensitive to the level and volatility of both short- and long-term interest rate fluctuations compared with sector-specific REITs across Japan, Australia, Singapore and the USA over the full sample period. Time-varying results have been found in this study. This may be attributed to a diversified REIT portfolio comprising multiple property sectors. These findings confirm the existence of REIT specialisation value across these four markets in the Pacific Rim from the aspect of interest rate sensitivity. As noted by Liow and Huang (2006), the lack of significance on the interest rate level and volatility effects on sector-specific REITs in the region may imply that sector-specific REITs were characterised by stronger interest rate risk aversion and interest rate hedging actions than diversified REITs over the sample period, particularly for office and specialty REITs across these four markets. Among sector-specific REITs, retail and residential REITs were generally more sensitive to long-term interest rate changes in both the US and Australian markets. Industrial REITs was vulnerable to changes in both short- and long-term interest rates in the USA and Japan. On the other hand, office and specialty REITs were generally immune to fluctuations in the level and volatility of both short- and long-term interest rates across these four markets.

Differences in signs and magnitudes among different property types of REITs can be attributed to the distinct lease structures of each property sector, since the term structure of property leases can be substantially impacted by the interest rate risk (Grenadier, 1996, 2005; Clapham and Gunnelin, 2003; Crosby *et al*., 2003, 2006; Ambrose and Yildirim, 2008; Agarwal *et al*., 2011). As noted by Miles and McCue (1982), residential properties are leased on a short-term basis, while office, retail and industrial properties are leased on a long-term basis. In the findings of Crosby *et al*. (2006), the rent-weighted lease length was 14.4 years for retail properties, 10.1 years for industrial properties and 8.9 years for office properties in 2003. Additionally, Crosby *et al.* (2003) report that retail properties are more volatile than office and industrial properties, due to the existence of percentage rents in the retail property leasing. These findings may result in retail and residential REITs being more sensitive to interest rate changes compared with the other property types of REITs. Furthermore, industrial REITs was one of the most susceptible REIT sub-sectors to interest rate changes across these four markets before the GFC, whereas it was immune to fluctuations in interest rates after the GFC. The changing trajectory of industrial REITs can be attributed to alterations in risk-return attributes of industrial REITs, since I&L REITs have moved from traditional industrial property structures to logistics property formats since the GFC, in order to gain strategic exposure to recent e-commerce trends, as documented by Lin *et al*. (2020).

Time-varying patterns on the interest rate sensitive of sector-specific REITs have been detected. The full period results were generally consistent with the post-GFC findings but slightly different from the pre-GFC outcomes. This can be elucidated by the fact that the coverage of the full study period largely overlapped with the post-GFC context, including the GFC period, which has been seen as the most volatile period in the recent international property investment space (Newell and Razali, 2009; Lee *et al*., 2016). This implies that the risk premia and the interest rate level and volatility effect vary over time.

Importantly, these findings have seen varying interest rate sensitivity of REITs among different property sectors and across these four markets. The disparities in the magnitude and direction of the sensitivity in the interest rate level and volatility for each REIT sub-sector across Japan, Australia, Singapore and the USA should be considered in REIT portfolio construction and management, in order to reduce or mitigate interest rate risk exposure. The findings also confirm that different property types of REITs featured distinct risk attributes from each other, since each property sector has different market fundamentals.

10.2.6 Summary of Key Findings

Table 10-1 summarises the key findings in relation to the six research questions. An overall picture from these findings is that sector-specific REITs outperformed diversified REITs on all research aspects assessed in this study. Therefore, the assertion of REIT specialisation value has been confirmed in the Asia-Pacific region and the USA from July 2006 to December 2018. In addition, the investment distinctions of REITs among different property sectors and across various markets in the region have been validated over the full sample period. The following section will discuss the practical and theoretical contributions to the discipline of property investment.

Table 10-1: Summary of key findings for each research questions

Research question	Key Findings
RQ1	1. Sector-specific REITs delivered stronger risk-adjusted returns than diversified REITs across Japan, Australia and Singapore over the full sample period. 2. Sector-specific REITs were stronger portfolio diversifiers than their diversified counterparts across Japan, Australia and Singapore over the full sample period. 3. Sector-specific REITs were distinct risk-adjusted investment assets from diversified REITs across Japan, Australia and Singapore over the full sample period.
RQ2	1. Sector-specific REITs played a more significant role than diversified REITs, stocks and bonds in domestic mixed-asset portfolios across Japan, Australia and Singapore over the full sample period. 2. REIT specialisation value has been validated across various domestic markets in the Asia-Pacific region.
RQ3	1. Dominant portfolio compositions of sector-specific REITs were validated in regional and global mixed-asset portfolios over the full sample period. 2. The Asia-Pacific REIT specialisation value has been reinforced in the regional and global investment contexts.
RQ4	1. Portfolio returns, risk, geographical and sectoral diversifications, and asset allocations of five different property types of regional REIT-based portfolios were assessed and discussed. 2. The investment distinctions of REITs among different property sectors and across various markets have been identified.
RQ5	1. Sector-specific REITs were less sensitive to interest rate changes compared with diversified REITs across Japan, Australia and Singapore over the full sample period. 2. Retail and residential REITs were more susceptible to interest rate movements compared with the other sector-specific REITs across Japan, Australia and Singapore over the full sample period. 3. Industrial REITs was only vulnerable to interest rate fluctuations across Japan, Australia and Singapore before the GFC; 4. REIT specialisation value has been validated from the aspect of interest rate sensitivity across various domestic markets in the Asia-Pacific region.
RQ6	1. REIT specialisation value has been strengthened in the USA from aspects of risk-adjusted performance, portfolio diversification benefits, optimal and constrained mixed-asset portfolios, and interest rate sensitivity over the full sample period. 2. The investment distinctions of REITs among different property sectors has been confirmed in the USA.

Source: Author’s compilation

10.3 PRACTICAL INVESTMENT IMPLICATIONS OF THE STUDY

The results of this dissertation have several profound practical investment implications. Firstly, these findings offer a more comprehensive understanding of the dynamic risk-return characteristics of sector-specific REITs across five different property sectors (office, retail, industrial, residential and specialty REITs) and across various domestic jurisdictions in the Asia-Pacific (Japan, Australia and Singapore) and US contexts, as well as in regional and global contexts. It is expected that this research will assist international institutional investors seeking listed property exposure, particularly REMFs/PSFs (e.g. Vanguard, Invesco, UBS, LaSalle) and income-oriented investors, in making well-informed and strategic listed property investment decisions regarding sector-specific REITs across Japan, Australia, Singapore and the USA, as well as in the Asia-Pacific region more broadly.

Secondly, these empirical findings will be particularly beneficial for property fund managers constructing and managing portfolios with REITs in the Asia-Pacific region and the USA, since the dynamic risk-return profiles of sector-specific REITs have been assessed from multiple investment perspectives, addressing both investment and risk management dimensions. Specifically, many property funds are increasingly including REITs in their local, regional and international portfolios. According to the assertion of specialisation value – that a single-business segment trades at a premium over their diversified counterparts – property management could be potentially more effective when a REIT is specialised by property type compared with a diversified REIT portfolio. The existence of REIT specialisation value in the Asia-Pacific region and the USA has been validated by this research. This implies that the strong investment performance of sector-specific REITs should make them an attractive property investment product, co-existing with mainstream asset classes in mixed-asset portfolios at domestic, regional and global levels, with desirable portfolio diversification benefits for institutional investors in the region. The findings strongly suggest that institutional investors seeking listed property investment exposure in the region should consider including different property types of REITs, rather than their diversified counterparts, in their local, regional and international portfolios. It is clear that sector-specific REITs are a preferable REIT structure for addressing institutional investor appetite, reflecting the prominent role of sector-specific

REITs in the international REIT markets, particularly in the Asia-Pacific over the last 12 years. Hence, REIT investment advisors should recommend sector-specific REITs to clients who are willing to establish a new REITs in Japan, Australia, Singapore and the USA.

As for portfolio diversification strategies, a sectoral REIT investment strategy across these four markets offered greater portfolio diversification benefits than inter-stock and inter-REIT investment strategies. The diversity of sector-specific REITs can translate directly into attractive sectoral diversifications for investors who employ a sectoral REIT investment strategy across these four domestic markets or in the Asia-Pacific region. The stronger portfolio diversification traits of sector-specific REITs suggest that institutional investors should actively make their own sectoral portfolio diversification decisions by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio comprising multiple property sectors. This is consistent with the findings of Capozza and Seguin (1999), who reported on institutional investors intending to make their own sectoral diversification decisions.

Reflecting the practical mandate of international property funds to gain exposure to regional REIT-based portfolios, five different property types of regional REIT-based portfolios in the Asia-Pacific were investigated, including cross-country sector-specific REITs across Japan, Australia, Singapore and the USA. The rigorously empirical findings regarding portfolio returns, risk, geographical and sectoral diversifications, and asset allocations of five different property types of regional REIT-based portfolios offer a comprehensive overview of, and insights into, how to structure REIT portfolios to reflect that mandate, as well as geographic and sectoral diversification strategies via various diversification approaches.

Regarding interest rate risk management, diversified REITs was shown to be more sensitive to interest rate changes than sector-specific REITs. This may be attributed to a diversified REIT portfolio including multiple property sectors. In contrast, the lower exposure to interest rate risk of sector-specific REITs may imply a stronger interest rate risk aversion and hedging actions. These are particularly valuable to international property investors constructing and managing portfolios containing REITs in the region, so as to reduce or hedge interest rate risk exposure. Property investors with expertise in portfolio construction and management are advised to be aware of the disparities in the magnitude and direction of the sensitivity to interest rate level and volatility across different property types of REITs and various markets in the Asia-Pacific region and the USA. Time-varying interest rate sensitivity of sector-specific REITs enables investors to capture the dynamic interest rate risk management for different property types of REITs in local and international investment portfolios.

Of sector-specific REITs, property investors should recognise that retail and residential REITs are the most susceptible sectors to interest rate fluctuations. This can be attributed to the lease structures of these two REIT sub-sectors, since the term structure of property leases can be substantially impacted by the interest rate risk (Ambrose and Yildirim, 2008; Agarwal *et al*., 2011). Specifically, residential properties are leased on a short-term basis, while office, retail and industrial properties are leased on a long-term basis (Miles and McCue, 1982). In addition, retail properties are typically more volatile than office and industrial properties, due to the use of percentage rent in their lease structures (Crosby *et al.*, 2003). Furthermore, industrial REITs was shown to be vulnerable to interest rate movements prior to the GFC, but was immune to interest rate changes after the GFC. This may be attributed to the changing market trajectory of industrial REITs, which have moved from traditional industrial property structures to logistics property formats in order to capitalise on strong e-commerce and omnichannel retail trends in the post-GFC context (Lin *et al*., 2020). For example, Goodman increased logistics property exposure in its property portfolios from 78% in 2007 to 94% in 2018, while downsizing traditional industrial property allocations by 16% (Goodman, 2018). This may result in changing risk-return attributes of industrial REITs in the region. These rigorously empirical findings provide significant insights into interest rate risk management for property portfolio managers and policymakers in the Asia-Pacific region and the USA.

Lastly, the comparison of sector-specific REITs has identified a clear investment distinction among different types of property sectors and across these four major REIT markets. The distinct risk-adjusted returns, portfolio diversification benefits, portfolio allocations and interest rate sensitivity of different property types of sector-specific REITs confirm that risk-return attributes of different property types of REITs can be fundamentally different across property types. This is due to each property sector being characterised different asset durability, investment lags, supply or demand elasticities and lease structures and the use of credit to finance development from one and the others (Miles and McCue, 1982; Eichholtz *et al*., 1995; Wheaton, 1999; Crosby *et al*., 2003, 2006; Hamelink and Hoesli, 2004; Yavas and Yildirim, 2011; Chong *et al*., 2012; Hoesli and Oikarinen, 2012, 2016; Geltner *et al*., 2014; Hoesli *et al*., 2015; Lin *et al*., 2019a). These differences may result in considerable divergence between risk-return attributes of different REIT sub-sectors. The distinct risk-return profiles of each REIT sub-sector introduced in this study would certainly be particularly important for individuals and institutional investors seeking listed property exposure in Japan, Australia, Singapore and the USA, as well as in the Asia-Pacific region.

Although past performance offers no guarantee of future performance, all of these rigorously empirical findings have painted a clear picture regarding sector-specific REITs as offering effective and liquid listed property investment exposure in the Asia-Pacific region and the USA, as well as of an increasingly institutionalised property sector going forward. The recent COVID-19 pandemic has severely impacted on the Asia-Pacific and international property investment space (RCA, 2020; NAREIT, 2020a). The market has been seen a 26% year-on-year decline in office transactions, 34% in retail, 10% in residential and 50% in specialty properties in the international context in the first half of 2020. Bucking this trend, industrial property transactions have increased by 27% (RCA, 2020). In the Asia-Pacific, China’s commercial property transactions rebounded in Q2 of 2020, with investment in office properties increasing by 172%, retail properties by 2% and industrial properties by 100% YOY. Meanwhile, Japan’s and Australia’s residential property deal volumes grew by 217% and 255% YOY, respectively (Benjamin, 2020). REIT rent collections by five property sectors (office, retail, industrial, residential and specialty REITs) have rapidly improved from April and July in 2020 (NAREIT, 2020b). During the COVID-19 pandemic, high-tech- and e-commerce-related REIT sectors (e.g. I&L REITs, data centre REITs) have created new paths in the Asia-Pacific and international property investment space, due to the spread of internet communications and the rise of e-commerce (NAREIT, 2020a).

10.4 SUMMARY OF RESEARCH CONTRIBUTIONS

In the international property literature, the prevailing role of sector-specific REITs has been witnessed in the Asia-Pacific and international REIT contexts, reflecting the potential of the existence of REIT specialisation value in the Asia-Pacific. The assertion of specialisation value has been asserted in the finance literature, positing that a single-business segment trades at a premium over their diversified counterparts. However, no comparable study has been devoted to REIT specialisation value in the Asia-Pacific, or has offered updated empirical evidence in the post-GFC context. Given the fact that various property sectors feature distinct market cycles, it is imperative to validate REIT specialisation value by demonstrating distinctions between different property types of REITs and diversified REITs on a risk-return basis. This research has highlighted sector-specific REITs as a more effective listed property investment conduit than diversified REITs. In doing so, this study has contributed to a more comprehensive understanding of the different property types of REITs' performance, portfolio diversification benefits and roles in mixed-asset portfolios at domestic, regional and global levels, and their sensitivity to the time-varying interest rate risk. It has also included multi-dimensional investment perspectives, addressing both investment and risk management dimensions.

In answering the six research questions, this study has contributed to the existing literature in a number of ways. First of all, this is the first study to assess the added-value and strategic role of different property types of REITs across Japan, Australia and Singapore from July 2006 to December 2018, by the use of constructed REIT sub-sector series in the region. The current REIT sub-sector indices across these three markets from major index providers (e.g. S&P, MSCI, NAREIT) can only be tracked back to September 2011. To expand the data time horizon to July 2006, the coverage of the sample period has made the empirical analyses more balanced by including both the bull and bear market cycles – and the GFC, which is seen as the most volatile period by international scholars and practitioners. This is despite previous literature on the international REIT market mostly focusing on the pre-GFC period or the post-GFC period. This study has contributed to a fuller understanding of the dynamic investment performance of different property types of REITs in the Asia-Pacific region.

Secondly, this study is the first analysis to offer international evidence of REIT specialisation value in the Asia-Pacific region. The findings are expected to aid international institutional investors, particularly REMFs/PSFs and income-oriented investors, to make well-informed investment decisions regarding different property types of REITs. Other literature has yet to offer empirical analysis on the REIT specialisation value after the GFC. This study has contributed to the literature by offering rigorously updated findings concerning REIT specialisation value, validating the results of this research against US-REITs, the largest REIT market in the international context.

Thirdly, unlike previous studies – which, by taking different property types of REITs as a hybrid specialised REIT portfolio, ignore the fact that various property sectors may characterise distinct market cycles – this study is the first to compare different property types of REITs with diversified REITs on a risk-return basis, and has comprehensive insights for property investors seeking listed property exposure in the Asia-Pacific region and the USA. This is given that the returns, risk, risk-adjusted returns and portfolio diversification benefits are the critical criteria used by property investors and fund managers in investment decision-making.

Fourthly, this study has contributed to a comprehensive understanding of the roles of different property types of REITs in mixed-asset portfolios in domestic, regional and global investment contexts compared with diversified REITs, assessed by the construction of simulated efficient portfolios, and optimal and constrained asset allocation strategies. This is particularly beneficial for international property investors, since these rigorously empirical analyses have strengthened sector-specific REITs as a more effective listed property investment vehicle for international property investors seeking listed property exposure in the Asia-Pacific region and the USA.

Fifthly, five different property types of regional REIT-based portfolios have been constructed in order to reflect the practical mandatory of international property funds gaining exposure to regional REIT-based portfolios from a practical point of view, rather than country-specific portfolios. These regional REIT-based portfolios include Asia-Pacific office, retail, industrial, residential and specialty REIT-based portfolios, which comprise the corresponding cross-country sector-specific REITs across Japan, Australia, Singapore and the USA. This has not been empirically explored previously. In doing so, this study has enhanced international property investors' understanding of the investment performance, geographic and sectoral portfolio diversifications, portfolio allocations of different property types of regional REIT-based portfolio, as well as how they should structure their REIT portfolios under these mandates.

Sixthly, this study is the first analysis to provide rigorously empirical evidence on the interest rate sensitivity of different property types of REITs across various markets in the Asia-Pacific region. Given the historically low interest rate level since the GFC, practitioners and scholars have extensively discussed how REITs will respond to future rises in interest rates. Previous REIT scholars have primarily focused on composite REITs, with no comparable study devoted to the REIT sub-sectors. The disparities in the magnitude and direction of the sensitivity in the interest rate level and volatility for each REIT sub-sector across different markets in the Asia-Pacific are particularly important to international property investors, who construct and manage portfolios with different property types of REITs in the region, so as to reduce or hedge against interest rate risk exposure. The time-varying sensitivity of sector-specific REITs to interest rate changes enhances investors' insights into the dynamic risk management for different property types of REITs in local, regional and international investment portfolios.

Seventhly, since the primary findings regarding superior risk-adjusted returns, portfolio diversification benefits, roles in mixed-asset portfolios at domestic, regional and international levels, and interest rate sensitivity of different property types of REITs have been validated in this study, the existence of REIT specialisation value has been demonstrated in the Asia-Pacific region. To reinforce the REIT specialisation value in the post-GFC context, the study extended these analyses to US-REITs. These have not been empirically explored in the USA in the post-GFC context. In particular, the empirical assessment of the interest rate sensitivity of different property types of REITs in the USA requires daily US-REIT sub-sector indices to be constructed to capture more intuitive linkages between REIT sub-sectors and interest rate level and volatility changes.

Eighthly, to assess the dynamic investment performance of different property types of REITs at domestic, regional and global levels, the aggregate regional REIT sub-sector indices in the Asia-Pacific have been constructed, including regional diversified, office, retail, industrial, residential and specialty REIT indices in the Asia-Pacific, as well as domestic REIT sub-sector series across Japan, Australia and Singapore, and daily US-REIT sub-sector series. These constructed YCL/UNSW series have not been available publicly prior to this study and will be a valuable ongoing research platform for future Asia-Pacific sector-specific REIT analyses.

Lastly, this research has pioneered the rigorously empirical investigation of different property types of REITs across four different markets. Therefore, this study not only offers an empirical analysis of the investment performance for different property types of REITs in these four markets for the first time, but also contributes to assessing investment distinctions across these different markets. It is expected to provide a more comprehensive insight into the added-value and strategic role of different property types of REITs for international property investors seeking listed property investment exposure in the Asia-Pacific region and the USA.

10.5 LIMITATIONS OF THE STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH

While this study has supported the existence of REIT specialisation value across Japan, Australia, Singapore and the USA, limitations in both data and methodologies constraint the scope of this research, as follows.

The first limitation is the short time series of sector-specific REITs data used for Japan, Australia and the USA. Since the Singapore REIT sub-sector indices can only be tracked back to July 2006, full-period historical data for sector-specific REITs in Japan, Australia and the USA were lacking, restricting the ability to perform a long-term quantitative analysis of risk-return attributes of sector-specific REITs across these three markets. This creates the potential for future studies assessing a full market cycle of sector-specific REITs across these three markets, rather than a specific timeframe.

Secondly, property investment via a non-listed vehicle (separate accounts, joint ventures or club deals) is the mainstream route for large-scale global institutional investors. However, direct property total return series were excluded from these analyses due to comparability issues. Specifically, the performance data from major index providers (e.g.

NREIF, INREV, ANREV, MSCI, RCA) are limited to annual data, and the coverage was over a shorter timeframe (mostly from 2009). In addition, this study aims to validate REIT specialisation value in the Asia-Pacific region, rather than specialisation value of direct property. This creates the potential for future studies to validate the specialisation value of a non-listed property investment vehicle by using direct property sub-sector data. It should be noted that direct property sub-sector indices are available on a subscription-only basis from MSCI. Asset allocation analyses should also be customised to reflect the actual allocation strategies used by institutional investors.

Thirdly, the REIT sub-sectors used in this study were those categorised by the GICS. There are the other property types of REITs – including self-storage, hotel, data centre, infrastructure, farmland and timberland – which have yet to be assessed separately. In addition, the NAREIT offers sub-categories of retail and residential REITs, such as freestanding, regional malls, shopping centres, single-family homes, multifamily homes and manufactured homes. Future studies are recommended to assess the risk-return attributes of these REIT sub-sectors. Since Asia-Pacific hotel and health care data are too thin, this study has included these two sectors in the specialty REIT category. Further studies are advised to investigate the investment performance of these two sectors respectively.

Fourthly, given that REIT sub-sector indices in the other markets in the Asia-Pacific (Hong Kong, Malaysia, New Zealand, Taiwan, Thailand, South Korea, Pakistan, Indonesia, India, Philippines and China) are too thin, this study has focused on the major REITs markets in the Asia-Pacific region. When these other markets have matured, the extension of the analyses is expected to attract both scholars' and practitioners' interest.

Fifthly, while the standard deviation was used in this study as the risk measures, there are alternative risk measures, such as beta and downside risk. Further, the Treynor and Sortino ratios are recommended as alternative risk-adjusted return measures. The Treynor ratio compares expected excess returns of an asset to its expected systematic market risk (beta), measuring risk-adjusted returns of an asset. The Sortino ratio considers both downside and upside volatility (Lee, 2009). All of these would provide investors with a fuller understanding of the risk-adjusted attributes of an asset. Additionally, the assumption of

Modern Portfolio Theory (MPT) is measured by the standard deviation. To provide a more thorough picture of the volatility of sector-specific REITs, a downside risk portfolio is suggested to be deployed for future studies.

Sixthly, digital tools and marketing have been broadly employed in the property investment space (Low *et al.*, 2020), as have sustainability concepts (Eves and Kippes, 2010; Reed, 2018). Future studies are advised to scrutinise the smart digital marketing and sustainability of sector-specific REITs in the Asia-Pacific.

Seventhly, the interest rate sensitivity of sector-specific REITs assessed by the GARCH-M specification was at a market level. No comparable study has considered the issue of interest rate risk from the firm-level perspective. It will be interesting to explore the linkages between the individual characteristics of the firms and interest rate movements. This extends beyond these six REIT sub-sector markets in the Asia-Pacific region.

Lastly, since the COVID-19 pandemic has severely impacted on the Asia-Pacific investment space, particularly for retail and hospitality REITs (RCA, 2020; NAREIT, 2020a), future research is recommended to assess how the pandemic may change the perceptions of risk and returns of these types of REITs.

These recommendations note the potential for future studies of sector-specific REITs in the Asia-Pacific region and the USA. Although the scope of this study can be further extended in multiple directions, this research has achieved its ultimate goal of offering insightful empirical analyses on the dynamic risk-return attributes of different property types of REITs in the Asia-Pacific region and the USA, and has contributed to the existing body of knowledge in the discipline of property investment.

10.6 CONCLUDING REMARKS

The recent market trajectory of different property types of REITs in the international REIT investment space has seen sector-specific REITs as the preferable REIT structure for investors seeking listed property exposure in the international context. The rigorous analyses undertaken in this study have validated the existence of REIT specialisation value across the Asia-Pacific region and the USA, highlighting the superior risk-adjusted returns, portfolio diversifications, roles in mixed-asset portfolios at domestic, regional and global levels, and lower sensitivity to the interest rate risk of different property types of REITs compared with their diversified counterparts. These findings strongly suggest that sector-specific REITs are more effective listed property investment vehicle than diversified REITs. The unique and appealing risk-return characteristics of sector-specific REITs indicate that institutional investors should actively control their own sectoral portfolio diversification by investing in different property types of REITs, rather than passively relying on a diversified REIT portfolio with multiple property sectors. Furthermore, the findings of the thesis have validated the investment distinctions between REITs across different property sectors and across various markets, such as Japan, Australia, Singapore and the USA. This has highlighted the importance of a dedicated study of each REIT sub-sector in different REIT markets, in order to provide further insights into sector-specific REITs in the Asia-Pacific region and the USA.

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