Institutional Investors, Corporate Innovation, and Information

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Institutional Investors, Corporate Innovation, and Information

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fulfillment of the requirements for the degree of
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Abstract 350 words maximum: (PLEASE TYPE)

This thesis contains three stand-alone studies that relate to institutional investors, corporate innovation, and information.
The first study examines the role of foreign institutional investors in promoting firm-level innovation around the world. The baseline results show a positive effect of foreign institutional ownership on innovation. Using a difference-in-differences approach that relies on plausibly exogenous variation in foreign institutional ownership created by a quasi-natural experiment, as well as an instrumental variable approach, this study shows that the effect is causal. Three channels through which foreign institutions spur innovation are proposed. The results show that foreign institutions promote innovation by providing active monitoring, by providing insurance for firm managers with career or reputation concerns against the risk of innovation failures, and by facilitating technology transfers from high-innovation countries. This study provides new insights into the real effects of foreign institutions on technological innovation.
The second study examines how the heterogeneity of institutional investors is related to information asymmetry. Using two widely used proxies for information asymmetry, this study finds that heterogeneity has a significant effect on information asymmetry that is robust to the use of firm controls, firm fixed effects, and different estimation methods. Specifically, investment horizon, ownership concentration, and type of institutional investors, as well as the number of institutional investors are significantly related to information asymmetry. This study highlights the role of the heterogeneity of institutional investors in shaping a firm's information environment.
The third study examines the roles of institutional investors in explaining the empirical controversy over the pricing effect of information risk arising from information asymmetry between informed and uninformed traders. Based on both the portfolio approach and the Fama-MacBeth regression, this study finds that although there is a pricing effect of information asymmetry, this relationship exists only among the stocks with low levels of institutional ownership. There is no such an effect for stocks with high institutional ownership levels, suggesting that investors do not require compensation for information risk to hold these stocks.

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Abstract

This thesis contains three stand-alone studies that relate to institutional investors, corporate innovation, and information.

The first study examines the role of foreign institutional investors in promoting firm-level innovation around the world. The baseline results show a positive effect of foreign institutional ownership on innovation. Using a difference-in-differences approach that relies on plausibly exogenous variation in foreign institutional ownership created by a quasi-natural experiment, as well as an instrumental variable approach, this study shows that the effect is causal. Three channels through which foreign institutions spur innovation are proposed. The results show that foreign institutions promote innovation by providing active monitoring, by providing insurance for firm managers with career or reputation concerns against the risk of innovation failures, and by facilitating technology transfers from high-innovation countries. This study provides new insights into the real effects of foreign institutions on technological innovation.

The second study examines how the heterogeneity of institutional investors is related to information asymmetry. Using two widely used proxies for information asymmetry, this study finds that heterogeneity has a significant effect on information asymmetry that is robust to the use of firm controls, firm fixed effects, and different estimation methods. Specifically, investment horizon, ownership concentration, and type of institutional investors, as well as the number of institutional investors are significantly related to information asymmetry. This study highlights the role of the heterogeneity of institutional investors in shaping a firm's information environment.

The third study examines the roles of institutional investors in explaining the empirical controversy over the pricing effect of information risk arising from information asymmetry between informed and uninformed traders. Based on both the portfolio approach and the Fama-MacBeth regression, this study finds that although there is a pricing effect of information asymmetry, this relationship exists only among the stocks with low levels of institutional ownership. There is no such an effect for stocks with high institutional ownership levels, suggesting that investors do not require compensation for information risk to hold these stocks.

Chapter 1

Introduction

1.1 Research Background, Motivations, and Major Findings of the Thesis

Institutional investors have been playing an increasingly important role in the global capital market. According to International Financial Services London (2007), total assets under management by major global institutional investors reached 81.9 trillion US$ by the end of December 2007. Institutional investment grew from 15% of aggregate ownership of equities in 1980 to more than 60% by 2007 in the U.S. market. Moreover, the role of institutional investors has rapidly become important in emerging markets (Khorana, Servaes, and Tufano, 2005).

Because of the paramount importance of institutional investors in the financial market, an intriguing question that has been asked is what roles institutional investors play in the financial market as well as in the economy. Although this subject matter has induced a wealth of research on institutional investors, a number of important areas for investigation that have practical implications remain under-explored. The general purpose of this thesis is to provide a better understanding of the roles of institutional investors in the financial market and ultimately in the economy. Specifically, this thesis presents three independent empirical studies that examine the following research questions:

1. Do foreign institutional investors enhance or impede corporate innovation around the world?
2. How does institutional investors' heterogeneity affect information asymmetry between informed and uninformed investors?
3. Do institutional investors play a role in explaining the empirical controversy over the pricing effect of information risk that originates from information asymmetry?

The first study examines whether foreign institutional investors enhance or impede corporate innovation in domestic firms in non-U.S. economies around the world. Research has shown that a key factor in the internationalization of capital markets is the growing importance of foreign institutional investors. For instance, Li et al. (2006) and Ferreira and Matos (2008) find that institutional investors are the major players not only in developed markets but also in emerging markets. According to FactSet, foreign institutional ownership accounts for more than 50% of total institutional ownership for non-U.S. firms as of 2010, which suggests that foreign institutions represent a non-negligible force that can influence corporate policies.

Although innovation is a crucial driver of economic growth (Solow, 1957), motivating innovative activity remains a challenge for firms in less developed economies. Unlike routine tasks that rely on well-established methods and approaches, innovation involves the exploration of unknown methods and approaches, which is full of uncertainty and is likely to result in failure (Holmström, 1989). Despite the fast-growing body of literature that theoretically and empirically examines various ways to promote firm innovation, there is little insight into the role of foreign institutional investors in firm innovation from a global perspective. Therefore, understanding the role of foreign institutional investors in motivating innovation is an important research question, not only because of the crucial role of technological innovation in a country's economic growth but also because of the important role of foreign institutional investors in the global financial market. The first study fills this gap in the literature by investigating the role of foreign institutional investors in firm-level innovation outside of the United States.

Using a unique innovation dataset from a comprehensive database of firm-level global patents and citations, Thomson Innovation's Derwent World Patents Index (DWPI), coupled with firm-level institutional ownership data from Factset/Lionshares for 26 non-U.S. economies for the 2000–2010 period, the first study, for the first time in the finance literature, provides several new findings. First, it shows that foreign institutional ownership has a positive effect on firm innovation output. Second, using as identification strategies an instrumental variable approach as well as a difference-in-differences approach that relies on the plausibly exogenous variation in foreign institutional ownership that is generated by a quasi-natural experiment, it shows that this effect is causal. Third, this study explores three possible underlying economic mechanisms through which foreign institutional investors promote innovation, and document evidence that foreign institutions (i) act as active monitors, (ii) provide insurance for firm managers with career or reputation concerns against possible innovation failures, and (iii) promote technology transfers from high-innovation countries.

The second study examines how the heterogeneity of institutional investors affects information asymmetry between informed and uninformed investors in the U.S. equity markets. Although institutional investors are often treated as a homogeneous group of large investors, there are a number of dimensions along which institutional investors are heterogeneous. Institutional investors may differ in investment objectives, investment horizons, and ownership concentration, as well as the strength of monitoring incentives. These differences are likely to produce differential effects on investee firms' information environments. For instance, one group of institutional investors may have stronger incentives to monitor and pressure management, which could increase transparency and thus mitigate information asymmetry about the firm's fundamental value. On the contrary, another group may place greater emphasis on gathering information as inputs into trading strategies that speculate for short-term trading profits, suggesting that their involvement in a firm in the form of stock ownership can exacerbate the firm's information environment.

Despite this inherent institutional heterogeneity, there has thus far been limited comprehensive empirical evidence on how differences in institutional characters are related to information asymmetry at the firm level. This study fills this gap in the literature by examining the relationship between the different dimensions of institutional investor heterogeneity and information asymmetry. Using two widely used proxies for information asymmetry drawn from the market microstructure literature for a sample of publicly traded firms on the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX), this study document several findings as follows. While short-term institutional ownership is positively associated with information asymmetry, total institutional ownership, top-five largest institutional ownership, institutional ownership concentration, independent institutional ownership, long-term institutional ownership, and the number of institutional investors in the firm are negatively associated with information asymmetry. These results suggest that the heterogeneity of institutional investors is an important factor to consider in examining their roles in investee firms' information environments.

The third study examines what role institutional ownership plays in explaining the empirical controversy over the pricing effect of information risk that arises from information asymmetry between informed and uninformed traders in the U.S stock markets. This study is motivated by two competing views. On the one hand, traditional asset pricing theory (e.g., Fama (1970, 1991)) assumes that information risk has no pricing effect on expected returns because it is completely diversifiable. On the other hand, an influential set of papers has claimed that information risk arising from information asymmetry between informed and uninformed traders is systematic and thus un-diversifiable.[1] This study examines how the information asymmetry that is captured by two widely used proxies for information asymmetry drawn from the market microstructre literature, namely, the PIN measure of Easley, Hvidkjaer, and O'Hara (2002) and the $AdjPIN$ measure of Duarte and Young (2009), affects expected stock returns under a circumstance in which information asymmetry is

[1]For example, Easley et al. (1996), Easley, Hvidkjaer, and O'Hara (2002), Easley and O'Hara (2004), or Easley, Hvidkjaer, and O'Hara (2010).

likely to be in evidence and thus matters to asset pricing. The study proposes a hypothesis that the pricing effect of information asymmetry as captured by PIN and $AdjPIN$ should be significant (insignificant) only for stocks with low (high) levels of institutional ownership.

There are two primary reasons why the roles of institutional investors should be considered when examining the pricing effect of information asymmetry. First, because institutional investors are better able to provide effective monitoring (e.g., Shleifer and Vishny (1986), Grossman and Hart (1988), Gillan and Starks (2000), Gillan and Starks (2003)), their stock equity ownership of a firm can signal to the market that the severity of information asymmetry in the firm is likely to be mitigated by intensive institutional monitoring. Second, institutional investors are known to have informational advantages because of their ability to exploit the economy of scale in information production and processing so that they can act as a credible mechanism for transmitting information to other market participants (Stepanyan, 2011). Using both the portfolio approach and the two-pass Fama and MacBeth's (1973) regression framework, this study shows that although information asymmetry has a significant effect on expected returns, this pricing effect exists among only those stocks that have low levels of institutional ownership. This finding suggests that investors do require compensation for information risk to hold such stocks.

1.2 Contributions of the Thesis

This thesis makes several important contributions to the literature, as follows.

The first contribution is that compared with existing cross-country studies on innovation, this thesis uses a superior proxy for firm-level innovation in an international setting. Existing work on innovation typically uses either R&D expenditures from the Worldscope database (Brown, Martinsson, and Petersen, 2013) or the number of patents applied for to the U.S. Patent and Trademark Office (USPTO) (Hsu, Tian, and Xu, 2014). These measures, however, have several limitations. First, many firms do not report R&D expenditures in their financial statements due to differences in accounting standards across countries, but missing R&D information does not necessarily mean that these firms are not involved in innovative activity. Second, not all R&D investments result in the granting of patents. Third, many firms outside of the U.S. may not apply for patents to the USPTO, which suggests that using only U.S. patents as a proxy for a firm's total innovation output is likely to result in the underestimation of that firm's innovation output. In this thesis, patenting data are collected from the Derwent World Patents Index (DWPI) database compiled by Thomson Innovation, which is the most comprehensive source of global firm-level patent information. Patent data from this unique dataset enable this study to construct firm-level proxies for innovation that can potentially overcome the shortcomings in the existing studies.

The second contribution is that for the first time in the literature, this thesis identifies, and documents empirical evidence on, a new and key determinant of firm-level innovation from a global perspective: foreign institutional investors. A fast growing body of literature has examined various ways to promote innovation. For example, Manso (2011) finds that the optimal contracts that motivate innovation should tolerate failure in the short run and reward success in the long run. Nanda and Rhodes-Kropf (2013) argue that although financial markets drive innovation activity, the "hot" rather than "cold" market facilitates innovation. Empirical evidence shows that laws (Acharya et al., 2014; Acharya and Subramanian, 2009), financial market development (Hsu, Tian, and Xu, 2014), firm boundaries (Seru, 2014), stock liquidity (Fang, Tian, and Tice, 2014), financial analysts (He and Tian, 2013), banking competition (Cornaggia et al., 2014), labor unions (Bradley, Kim, and Tian, 2013), product market competition (Aghion et al., 2005), and corporate venture capital (Chemmanur, Loutskina, and Tian, 2014) all positively or negatively affect innovation. This thesis adds to this emerging strand of literature by providing solid evidence that shows that foreign institutions are key drivers of firm innovation, especially in less innovative economies.

The third contribution of the thesis is related to the literature on the economic consequences of foreign investment. On the one hand, foreign institutional investors, in the aftermath of the recent global financial crisis, are often criticized as speculators who target short-term trading profits instead of long-term value creation and thus destabilize the stock markets, especially in emerging economies. On the other hand, evidence shows that foreign institutional investors positively affect firm value and performance outside of the U.S. (Ferreira and Matos, 2008) and promotes global convergence of governance (Aggarwal et al., 2011) as well as financial reporting (Fang, Maffett, and Zhang, 2014) practices. This thesis sheds light on the important real effects of foreign ownership in terms of technological innovation.

The fourth contribution of this thesis is that it provides a comprehensive analysis of the relationship between different dimensions of institutional investor heterogeneity and firm-level information asymmetry in the U.S. equity markets. Empirical evidence in the thesis shows that investment horizon, ownership concentration, and type of institutional investors, as well as the number of institutional investors are all significantly associated with information asymmetry. This thesis highlights the important role of the different dimensions of institutional investor heterogeneity in shaping a firm's information environment.

The fifth contribution is that in examining the empirical controversy over the pricing effect of information risk that originates from information asymmetry in the U.S. stock markets and is captured by PIN and $AjdPIN$, this thesis identifies a circumstance in which information asymmetry is most likely to be in evidence and to exhibit the greatest pricing effect. Specifically, this thesis finds that information asymmetry exhibits a pricing effect only for stocks with low institutional ownership levels. There is no such an effect for stocks with high levels of institutional ownership. This evidence thus suggests that the question at issue is not as much about whether PIN and $AdjPIN$ adequately capture information asymmetry, but more about under which circumstances information asymmetry matters to asset pricing. Evidence in the thesis suggests that investors appear to require compensation for information risk only from stocks with low institutional ownership levels.

1.3 Structure of the Thesis

This thesis is organized into five chapters. Chapter 1 provides introduction. Chapter 2 examines the role of foreign institutional investors in corporate innovation around the world. Chapter 3 examines the relationships between the different dimensions of institutional investor heterogeneity and information asymmetry. Chapter 4 investigates the role of institutional investors in explaining the empirical controversy over the pricing effect of information asymmetry. Chapter 5 summarizes the thesis.

Chapter 2

Foreign Institutional Investors and Corporate Innovation Around the World

2.1 Introduction

Despite the vital role of technological innovation in a country's long-term economic growth (Solow, 1957), it remains a challenge for firms in less developed economies to motivate innovative activities. Unlike routine tasks that rely on well-established methods and approaches, technological innovation is full of uncertainty and is likely to result in failures (Holmström, 1989). Therefore, it is important to investigate the various factors that affect firm innovation, especially for firms outside of the United States. Although there is a fast growing body of the literature that examines, both theoretically and empirically, various ways to promote corporate innovation, there is little insight into the effect of foreign institutional investors on innovation from a global perspective. This study fills this gap in the literature by examining the roles of foreign institutional investors in firm innovation outside of the U.S.

According to FactSet, foreign institutional ownership accounts for more than 50% of total institutional ownership for non-U.S. firms, which suggests that foreign institutions represent a non-negligible force that can influence a firm's innovation policy. Based on existing theories, empirical findings, and prevailing views, this study proposes two competing hypotheses as to how foreign institutions affect innovation. The first hypothesis posits that foreign institutional investors, by imposing short-term pressure on managers and inducing managerial myopia,[1] impede firm innovation. By contrast, the second hypothesis postulates that foreign institutional investors enhance innovation. Three underlying economics mechanisms that foreign institutions are able to enhance firm innovation have been proposed. Foreign institutions could (i) act as active monitors to mitigate managerial myopia and slack, (ii) provide insurance against possible innovation failures for firm managers with career or reputation concerns, and (iii) promote technology transfers from high-innovation

[1]See, for example, Stein (1988) or Bushee (1998, 2001).

countries.

This study examines these hypotheses using innovation data for 26 non-U.S. economies for the 2000–2010 period. The data are from a unique database of global firm-level patents and citations, the Derwent World Patents Index (DWPI) complied by Thomson Innovation, which is a leading source of global patent information. The existing cross-country studies on innovation typically use either R&D expenditures from the Worldscope database or the number of patents applied for to the U.S. Patent and Trademark Office (USPTO) as innovation measures. Both of these measures, however, have limitations and flaws.[2] The measures of firm-level innovation that this study constructs based on firms' patents granted by both domestic and foreign patent offices are able to reflect firms' innovation output accurately and overcome the existing cross-country studies on corporate innovation

The baseline results show a positive relation between foreign institutional ownership and firm innovation output, consistent with the second hypothesis. The evidence shows that the economic effect is sizable: a one standard deviation increase in foreign institutional ownership is associated with a 7.8% increase in patent counts and an 11.3% increase in patent citations in the following year.

While the baseline results are consistent with the second hypothesis that foreign institutional investors promote innovation, an important concern is that foreign institutional ownership is endogenous. Unobservable firm heterogeneity that is correlated with both foreign institutional ownership and innovation could bias the results (i.e., the omitted variable concern), and firms with high innovation potential could attract more foreign institutional investors (i.e., the reverse causality concern). Consequently, a positive association between foreign institutional ownership

[2] Limitations of existing innovation measures used in cross-country studies are discussed in more details in Subsection 2.3.

and innovation output does not necessarily imply that foreign institutional investors promote firm innovation. To establish causality, this study employs two different identification strategies.

In the first identification strategy, this study uses a difference-in-differences (DiD) approach that relies on the plausibly exogenous variation in foreign institutional ownership that is generated by a quasi-natural experiment: the passage of the U.S. Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA). The JGTRRA was designed to lower dividend tax rates not only for U.S. firms but also for firms domiciled in foreign countries that have tax treaties with the U.S. Desai and Dharmapala (2011) find a substantial portfolio reallocation by U.S. institutional investors towards dividend paying equities in treaty countries following the passage of the JGTRRA. After initiation of the JGTRRA, dividend paying stocks in treaty countries become more attractive to U.S. institutional investors, which creates plausibly exogenous variation in foreign (i.e., U.S.) institutional ownership for these non-U.S. firms. After undertaking a number of diagnostic tests to ensure the satisfaction of the parallel trend assumption, the key identifying assumption of the DiD approach, this study finds that, compared to the pre-JGTRRA period, treatment firms generated 2.5 more patents and 4.2 more citations per year than control firms after the enactment of the JGTRRA.

In the second identification strategy, this study constructs an instrumental variable and uses a two-stage least squares (2SLS) analysis. Following the existing literature, this study uses the membership in the Morgan Stanley Capital International (MSCI) All Country World Index (ACWI) as an instrument for foreign institutional ownership. The 2SLS results confirm the positive effect of foreign institutional ownership on innovation and, more importantly, reveal the direction of potential bias if no attempt is made to appropriately control for endogeneity in foreign institutional ownership. Overall, both of these identification attempts suggest that foreign institutional investors have a positive, causal effect on firm innovation.

This study then explores three possible underlying economic mechanisms through which foreign institutions enhance firm innovation as postulated by the second hypothesis. First, the monitoring channel is examined. By classifying foreign institutional investors into independent versus grey investors and long-term versus short-term investors, this study shows that only independent and long-term foreign institutions play a significant role in enhancing firm innovation, while grey and short-term foreign institutions do not. This evidence suggests that foreign institutional investors enhance innovation through their active monitoring of the firms. Second, the study explores the insurance channel and finds that the sensitivities of CEO turnover and compensation to firm performance are lower in firms with greater foreign institutional ownership. These results suggest that foreign institutional investors provide insurance for managers with career or reputation concerns against possible innovation failures. Third, the technology spillover channel is examined. This study shows that only foreign institutions from high-innovation economies spur innovation, which is consistent with the conjecture that foreign institutional investors facilitate knowledge and technology transfers from high-innovation economies.

This study contributes to two strands of literature. First, it contributes to the emerging literature on finance and innovation. There is a fast growing body of literature that examines, both theoretically and empirically, various ways to promote innovation. Holmström (1989) shows that innovation activities may mix poorly with routine activities in an organization. Manso (2011) finds that managerial contracts that tolerate failure in the short run and reward success in the long run are best at motivating innovation. Nanda and Rhodes-Kropf (2013) argue that financial markets drive innovation activity and that "hot" rather than "cold" financial markets can facilitate innovation. Empirical evidence shows that laws (Acharya, Baghai, and Subramanian, 2014; Acharya and Subramanian, 2009), financial market development (Hsu, Tian, and Xu, 2014), firm boundaries (Seru, 2014), stock liquidity (Fang, Tian, and Tice, 2014), financial analysts (He and Tian, 2013), banking competition (Cornaggia et al., 2014), labor unions (Bradley, Kim, and Tian, 2013), product market competition (Aghion et al., 2005), and corporate venture capital (Chemmanur, Loutskina, and Tian, 2014) all positively or negatively affect innovation. Adding to this body of research, this study provides new evidence that foreign institutional investors are key drivers of firm innovation, especially in less innovative economies.

Second, this study contributes to the literature on the economic consequences of foreign investment. Evidence shows that foreign ownership affects firm value and performance outside of the U.S. (Ferreira and Matos, 2008), and promotes global convergence of governance (Aggarwal et al., 2011) as well as financial reporting (Fang, Maffett, and Zhang, 2014) practices. Also, foreign ownership, in the aftermath of financial liberalization, affects the cost of capital (Bekaert and Harvey, 2000), real wages (Chari, Henry, and Sasson, 2012), consumption growth volatility (Bekaert, Harvey, and Lundblad, 2006), and emerging equity market volatility (Bekaert and Harvey, 1997). This study instead focuses on the real effects of foreign ownership in terms of technological innovation.

The remainder of this chapter is organized as follows. Section 2.2 presents literature review and hypothesis development. Section 2.3 describes data, variables, and methodology. Section 2.4 presents baseline results. Section 2.5 reports robustness checks. Section 2.6 presents identification strategies. Section 2.7 explores possible underlying economic mechanisms. Section 2.8 concludes.

2.2 Literature Review and Hypothesis Development

Empirical and theoretical corporate finance literature has argued that foreign institutional investors may stifle corporate innovation. The managerial myopic theory of Stein (1988) suggests that managers may fail to invest in long-term projects due to market pressures on firms' short-term performance. This view is supported by Graham, Harvey, and Rajgopal (2005), who survey 401 chief financial officers (CFOs) in the U.S. and find that the majority of the CFOs sacrifice long-term value for short-term earnings because they are pressured to meet short-term earnings targets.

As a powerful market force, institutional investors can pressure managers to forgo long-term investments, such as innovation, in exchange for short-term revenue. In particular, Bushee (1998) provides evidence that certain types of institutional investors increase the probability that managers reduce investment in research and development (R&D) to manage earnings. Bushee (2001) shows that institutional investors could pressure managers into a short-term focus by overweighting short-term earnings potential and underweighting long-term earnings potential. More importantly, such managerial myopia may be significantly exacerbated by foreign institutional investors because they are often criticized as speculators who target short-term trading profits instead of long-term value creation (e.g., Brunnermeier and Nagel, 2004; Choe, Kho, and Stulz, 1999; De Long, Shleifer, Summers, and Waldmann, 1990; Kaminsky, Lyons, and Schmukler, 2004). The above discussions suggest that foreign institutional investors, by imposing short-term pressure on managers and inducing managerial myopia, may impede firm innovation. Therefore, the first hypothesis can formulated as follows:

Hypothesis 2.1: *Foreign institutional investors should impede firm innovation.*

By contrast, there are three strands of the literature that provides support for the hypothesis that foreign institutional investors enhance innovation. First, a large body of research has shown that institutional investors can actively intervene in firms to make substantial changes and create value (e.g., Burkart, Gromb, and Panunzi, 1997; Kahn and Winton, 1998; Shleifer and Vishny, 1986). As Gillan and Starks (2003) argue, due to independent positions and lack of conflicts of interest, foreign institutional investors play a crucial role in promoting governance changes in local firms. Aggarwal et al. (2011) find that foreign institutional investors are involved in monitoring investee firms worldwide. Because managers may have incentives to shirk (i.e., prefer a "quiet life") and hence avoid investing in high-risk innovative projects that are likely to require high effort (Bertrand and Mullainathan, 2003; Hart, 1983), active monitoring by foreign institutions can induce managers to invest in long-term, value-enhancing innovative activities and ultimately enhance innovation. This view is referred to as the *monitoring* channel in this study.

Second, the early work of Holmström (1989) suggests that innovation activities may mix poorly with relatively routine activities in an organization because innovation requires different incentive schemes. While prior research in economics has established that the standard pay-for-performance contracts are effective in inducing higher levels of effort and productivity (e.g., Lazear, 2000; Shearer, 2004), psychology literature shows that performance-based financial incentives are effective only for routine tasks and not for those that require creativity and experimentation (Amabile, 1996; McCullers, 1962; McGraw, 1978).

To reconcile these two competing streams of the incentive literature, Manso (2011) and Ederer and Manso (2013) show that optimal incentive contracts that motivate innovation should exhibit substantial tolerance for early failure and reward for long-term success. Because managers may dislike the risk innovation involves (Holmström, 1989), managers will under-invest in innovative activity due to their concerns over career and reputation risks. As Aghion, Van Reenen, and Zingales (2013) show, if incentive contracts cannot fully motivate innovation, institutional investors may step in to encourage firm innovation by providing managers with assurance against career and reputation risks that stem from early failures in innovation attempts. Thus, to the extent that foreign institutional investors represent a large proportion of institutional ownership in emerging economies, they can acquire sufficient power to insulate managers from punishment for innovation failures and hence encourage firm innovation. In this study, this view is termed the *insurance* channel.

Third, one strand of the economics literature has underlined the importance of knowledge spillovers by which investment in the creation of knowledge by one party create positive externalities on innovation for other parties (Jaffe, Trajtenberg, and Fogarty, 2000). There are a number of factors that affect knowledge spillovers, such as the mobility of highly skilled human capital (Agrawal, Cockburn, and McHale, 2006), international trade and foreign direct investment (Branstetter, 2006), and geographic location (Breschi and Lissoni, 2009; Jaffe, Trajtenberg, and Henderson, 1993; Keller, 2002). In a recent study of cross-border acquisitions, Guadalupe, Kuzmina, and Thomas (2012) find that foreign acquirers help managers to innovate by facilitating technology transfers to local markets. Therefore, foreign institutional investors from more innovative countries can facilitate the transfer of technological knowledge and enhance their investee firms. In this study, this view is termed the *technology spillover* channel.

In sum, the above discussions show that foreign institutional investors can enhance firm innovation through three channels: (i) by acting as monitors, (ii) by providing insurance against possible innovation failure risks to firm managers with career or reputation concerns, and (iii) by promoting technology transfers from high-innovation countries. Therefore, the second hypothesis can be formulated as follows:

Hypothesis 2.2: *Foreign institutional investors should enhance firm innovation*

2.3 Data, Variables, and Methodology

2.3.1 Data

This study uses a sample of publicly listed firms from 26 economies (excluding the U.S.) for the 2000–2010 period. Firm-level innovation variables are constructed based on the patent and citation data from the Derwent World Patents Index (DWPI) database complied by Thomson Reuters. The DWPI is a comprehensive collection of global patent information in English translated from over 30 languages. In 2013, for example, the DWPI contained patent data from 48 patenting authorities, covering 51 million patent documents and 23 million patent families across all innovation technologies.

Institutional ownership is obtained from the FactSet Ownership database, a leading source of global institutional ownership information. For equities traded outside of the U.S., FactSet collects ownership data directly from sources such as national regulatory agencies, stock exchange announcements (e.g., the Regulatory News Service in the U.K.), local and offshore mutual funds, mutual fund industry directories (e.g., European Fund Industry Directory), and company proxies and financial reports. Because the FactSet historical ownership data are available from 1999 only, sample selection in this study is restricted to the 2000–2010 period. Firms' accounting data are obtained from the Worldscope database.

To combine innovation, ownership, and accounting information from various databases, DWPI's standardized assignee names are matched with those of Worldscope because

DWPI provides only firm names but not stock identifiers. Based on the cleaning and matching procedures as specified on the patent database's website of NBER,[3] sample selection begins with all the DWPI patents, as well as the whole universe of firms from Worldscope that have firm names and non-missing SEDOLs. Both exact and fuzzy matching methods are used to match DWPI's standardized assignee names with those of Worldscope. To eliminate any lingering doubt in the data matching process, information about the sample firms from different newswire services and Internet sources are also manually sought. In this process, a firm is required to have innovation information in order to be included in the sample. In addition, a firm retained in the sample must have non-missing accounting information. Finally, an economy must have at least ten firms to be retained in the sample. The final sample covers 4,140 unique non-U.S. firms from 26 economies (with a total of 28,903 firm-year observations), of which 1,475 firms are located in emerging economies and 2,665 firms are located in developed economies. The country with the smallest number of firms in the final sample is New Zealand, which has 12 firms. The country with the largest number of firms is Japan, which has 1,239 firms. While this is not ideal as a sample as regards the number of firms in some of the countries, it should be noted that the final sample is an intersection of Thomson Innovation, Factset, and Worldscope, in which any firm without information on patenting during the 2000-2010 period or without accounting data is excluded from the analysis. In addition, the final sample is comparable to those used in closely related studies, such as the recent work by Brown et al. (2013). Given that it is a cross-country study which employs a new, superior measure of firm-level innovation in existing studies, the size of the final sample thus should be reasonable.

[3]For detailed information about the NBER patent and citation data cleaning and matching procedures, see `https://sites.google.com/site/patentdataproject/Home/posts/namestandardizationroutinesuploaded`.

2.3.2 Variables

This section describes the construction of variables in details. All variable definitions are provided in Appendix 2.

Firm-level Innovation Variables

Due to the lack of global patent data, prior studies either construct innovation measures based on R&D expenditures or use patents applied for to the U.S. Patent and Trademark Office (USPTO) as a proxy for a firm's total innovation activity (Hsu, Tian, and Xu, 2014). However, neither of the two measures is perfect for several reasons. First, many firms do not report R&D expenditures in their financial statements due to different accounting standards across countries but missing R&D information does not necessarily mean that those firms are not involved in innovative activities. Second, not all R&D investments lead to the granting of patents. Third, many firms may not apply for patents to the USPTO, which results in an underestimation of innovation output if only U.S. patents are used as a proxy for a firm's total innovation output. With information on firms' patents applied for to patent offices around the world as well as citations made to these patents, the DWPI database enables this study to construct more accurate firm-level measures of innovation and thus to overcome the limitations in the existing cross-country studies. All key information, such as patent assignee names, application number, application date, application country, the number of forward citations received by each patent, publication (grant) date, and publication country, is collected for the construction of firm-level measures of innovation.

Two firm-level measures of innovation are constructed. The first one is the total number of patent applications filed by a firm in a year that are eventually granted. The application year of patents is used rather than the grant year, because the application year is better able than the grant year to capture the actual time of innovation (Griliches, Pakes, and Hall, 1988). In the event that a patent in the DWPI records can be assigned to multiple assignees, it is scaled by the number of assignees that own it, assuming equal patent ownership. All patents in the DWPI database are categorized into three broad areas—chemical, engineering, and electronic and electrical engineering—which are further divided into 20 "Sections" or broad subject areas, designated A–M (Chemical), P–Q (Engineering) and S–X (Electronic and Electrical) (see Appendix 1 for details). If a patent belongs to more than one of these 20 groups, it is also normalized by the mean number of patent applications filed in a year for technology groups to which it belongs.

The second measure of innovation is the total count of citations received by each patent in subsequent years, scaled by the average citation count for the technology group of patents to which the patent of interest belongs. Compared with the first measure, this measure is superior for assessing the quality of a patent because it captures the economic value of innovation by distinguishing breakthrough innovations from incremental discoveries.

As with earlier work on innovation (e.g., Hall and Ziedonis, 2001), this study addresses several concerns over the innovation measures constructed using the DPWI data. The first one is the truncation problem that occurs due to the fact that patents appear in the DPWI database only after they are granted. To put it differently, as the time series moves closer to the last date in the dataset, patent data timed according to the application date will increasingly suffer from missing observations consisting of patents filed in recent years that have not yet been granted. This is because the lag between the application year of a patent and the grant year is significant (about two years on average). In addition, many patent applications are still under review and have not yet been granted. To adjust the truncation bias in patent counts, the sample period in this study is ended in 2010.

The second concern relates to the double counting problem, that is, a firm may submit patent applications for to—and be granted patents by—more than one patenting authority. The DWPI database makes it possible to retrieve patents that are granted by all the patenting authorities. In the case that patents are granted by multiple patenting authorities, only the record with the earliest grant date is used.

The third concern is due to the right-skewness of the distribution of patent grants in the study sample, with a median of zero, both of which are similar to what has been documented in the innovation literature (e.g., Acharya, Baghai, and Subramanian, 2014; Seru, 2014; Tian and Wang, 2014). To address this issue, both innovation measures are winsorized at the 99th percentile and then log-transformed for use as the main innovation variables in the regression analysis. To avoid losing firm-year observations with zero patents or citations, patent and citation counts are added to the value of one before taking natural logarithms ($Ln(1 + Patent)$ and $Ln(1 + Citation)$).

Country-level Innovation Variables

To examine one of the underlying economic mechanisms through which foreign institutional investors can enhance innovation, the technology spillover channel, country-aggregate patent data are collected from the World Bank patent database. Compared with the DWPI, the World Bank database provides aggregate country-level data that identify country residence of patent holders. For each country in each year over the 2000–2010 sample period, four country-level measures of innovativeness are constructed for 73 countries, which is the number of countries in which institutions in the sample in this study are domiciled.

The first measure is the total number of patent applications submitted by all residents of a country in a year scaled by its GDP ($Patent/GDP$). The second measure is the total number of patent applications submitted by all residents of a country in a year scaled by its total population ($Patent/Pop$). The third measure is the total number of patent applications submitted by all residents of a country in a year scaled by its total number of listed firms ($Patent/Firms$). The last measure is the total number of patent applications submitted by all residents of a country in a year scaled by its market capitalization ($Patent/Mcap$). Then, each of these country-level innovativeness measures is averaged over the 2000–2010 period. Finally, an institution's home country is defined as a high- (low-) innovation country if that country's measure is above (below) the median of all these 73 countries' measures.

Institutional Ownership Variables

Following the literature on institutional investors (e.g., Aggarwal et al., 2011), institutional ownership at the latest report date of a calendar year is used to construct the following ownership variables. In the case of a firm whose shares are not held by any institution in the FactSet Ownership database (missing ownership data), institutional ownership variables are set to zero after merging the ownership data with innovation and accounting data (Gompers and Metrick, 2001).

As this study focuses on the role of foreign institutional investors in firm innovation across countries, it follows prior literature (e.g., Chen, Goldstein, and Jiang, 2007; Ferreira and Matos, 2008) and classify institutional ownership into foreign institutional ownership and domestic institutional ownership based on the nationality of the institutional money manager. Besides, foreign institutional ownership is classified into independent institutions and "grey" institutions according to the potential for business ties that foreign institutions may have with local investee firms.

1. Foreign institutional ownership (FIO): This measure is the sum of shares held by all institutions domiciled in a different country than the country where the firm's stock is listed, as a percentage of the firm's total shares outstanding.
2. Domestic institutional ownership (DIO): This measure is the sum of shares held by all institutions domiciled in the same country as the country where the firm's stock is listed, as a percentage of the firm's total shares outstanding.
3. Independent foreign institutional ownership ($FIO_{Independent}$): This measure is the sum of shares held by all foreign mutual funds and investment advisors, as a percentage of the firm's total shares outstanding.
4. Grey foreign institutional ownership (FIO_{Grey}): This measure is the sum of shares held by all foreign bank trusts, insurance companies, pension funds, and endowments, as a percentage of the firm's total shares outstanding.
5. Long-term foreign institutional ownership ($FIO_{Long-term}$): This measure is the sum of shares held by all foreign institutions that hold the firm's stock for more than one year, as a percentage of the firm's total shares outstanding.
6. Short-term foreign institutional ownership ($FIO_{Short-term}$): This measure is the sum of shares held by all foreign institutions that hold the firm's stock for less than one year, as a percentage of the firm's total shares outstanding.
7. High-innovation foreign institutional ownership ($FIO_{HighInno}$): This measure is the sum of shares held by all foreign institutions that come from high-innovation countries, as a percentage of the firm's total shares outstanding, where high-innovation countries are defined as in Subsection 2.3.2.
8. Low-innovation foreign institutional ownership ($FIO_{LowInno}$): This measure is the sum of shares held by all foreign institutions that come from low-innovation countries, as a percentage of the firm's total shares outstanding, where low-

innovation countries are defined as in Subsection 2.3.2.

Control Variables

Following the extant literature on innovation, a full set of firm- and industry-level characteristics that can affect a firm's innovation output are controlled for in the regressions. For each firm i in year t, the vector of control variables includes firm size ($Ln(SALE)$), firm age ($Ln(AGE)$), investments in intangible assets (RD), capital expenditures ($CAEX$), asset tangibility (PPE), leverage (LEV), profitability (ROA), financial constraint measure of Kaplan and Zingales (1997) (KZ), growth opportunities (Q), and industry concentration (the Herfindahl-Hirschman Index, HHI). The squared Herfindahl-Hirschman Index ($HHISQ$) is used to mitigate the nonlinear effects of product market competition on innovation output (Aghion et al., 2005). All variables are winsorized at the top and bottom 1% percentiles to eliminate the effects of outliers.

2.3.3 Methodology

To examine whether foreign institutional investors impede or enhance firm innovation, the baseline regression model is specified as follows:

$$\begin{aligned} Ln(1 + Innovation_{i,j,t}) &= \alpha + \beta_1 FIO_{i,j,t-1} + \beta_2 DIO_{i,j,t-1} \\ &\quad + \gamma' X_{i,j,t-1} + \varphi_t + \phi_k + \omega_j + \varepsilon_{i,j,t}, \end{aligned} \tag{2.1}$$

where i, k, j, and t refer to firm i, industry k, country j, and year t, respectively. The dependent variable captures firm innovation outcomes: the natural logarithm of one plus the number of patents ($Ln(1 + Patent)$), and the natural logarithm of one plus the number of citations received by patents ($Ln(1+Citation)$), both measured in year t. Foreign institutional ownership and domestic institutional ownership are measured at the latest report date in year $t - 1$. X is a vector of firm and industry characteristics known to be related to innovation and as discussed in Subsection 2.3.2, all measured in year $t-1$. The specification includes year (φ_t), industry (ϕ_k), and country (ω_j) fixed effects.

The primary interest of this study is in β_1, which is the coefficient on FIO. If β_1 is negative and statistically significant, then Hypothesis 2.1 that foreign institutions impede innovation is supported. By contrast, a positive and significant β_1 will provide support for Hypothesis 2.2 that foreign institutions enhance innovation.

2.4 Empirical Results

2.4.1 Summary Statistics

Table 2.1 presents the summary of sample statistics for the 2000–2010 period.

Panel A reports the means of innovation and institutional ownership measures by country. "*Patent*" refers to the total number of patent applications filed by a firm in a year and "*Citation*" is the total number of citations received by its patents. Of all the markets in the sample, Japan has the largest number of firms (1,239), followed by Taiwan (583), Korea (572), and Canada (246). An average firm in the entire sample has about 3.99 patents granted per year and about 6.35 citations received by its patents. Firms in Belgium are awarded the largest number of patents per year (7.95), followed by firms in the Netherlands (7.44), Japan (5.51), Taiwan (4.76), Germany (4.01), and Switzerland (3.99). The pattern is broadly similar for citations. On average, a firm in developed markets has a larger number of both patents and citations (4.09 and 6.43, respectively) than that in emerging markets (3.70 and 6.07, respectively). For institutional ownership, an average firm in developed markets has a FIO that is slightly lower than DIO (4.86% vs. 5.07%), whereas the FIO of a firm in emerging markets is substantially higher than its DIO (3.55% vs. 0.67%); for the entire sample, FIO is greater than DIO , on average.

Panel B of Table 2.1 presents the descriptive statistics of firm characteristics. On average, a firm has a book value of assets of USD 278.66 million, an R&D to assets ratio of 3.10%, a capital expenditure to assets ratio of 5.40%, a PPE ratio of 28.50%, a leverage ratio of 21.2%, an ROA of 7.20%, and a Tobin Q of 1.57. The average length of time that a firm has had its stock listed on a stock exchange is 14.5 years.

Panel B: Summary Statistics

Variable	Firms	Firm-Years	Mean	STD	5%	25%	Median	75%	95%
Innovation Variables									
Patent	4,140	28,903	3.988	14.900	0.000	0.000	0.000	2.000	29.000
Citation	4,140	28,903	6.349	25.424	0.000	0.000	0.000	2.263	52.917
Ownership Variables									
FIO	4,140	28,903	4.475	8.674	0.000	0.000	0.801	5.115	20.552
DIO	4,140	28,903	3.770	7.355	0.000	0.000	0.525	4.292	18.602
Control Variables									
$Ln(TA)$	4,140	28,903	5.636	1.905	2.801	4.344	5.468	6.776	9.149
AGE	4,140	28,903	14.495	12.113	2.000	6.000	12.000	19.000	35.000
$Ln(SALE)$	4,140	28,903	5.465	2.103	2.049	4.203	5.430	6.796	9.009
HHI	4,140	28,903	0.253	0.259	0.027	0.072	0.146	0.339	0.931
$HHISQ$	4,140	28,903	0.131	0.247	0.001	0.005	0.021	0.115	0.866
RD	4,140	28,903	0.031	0.068	0.000	0.000	0.008	0.031	0.142
$CAEX$	4,140	28,903	0.054	0.053	0.004	0.019	0.039	0.071	0.161
PPE	4,140	28,903	0.285	0.182	0.026	0.138	0.270	0.405	0.620
LEV	4,140	28,903	0.212	0.181	0.000	0.052	0.189	0.327	0.537
ROA	4,140	28,903	0.072	0.121	-0.172	0.042	0.087	0.136	0.235
Q	4,140	28,903	1.568	1.397	0.672	0.917	1.145	1.639	3.792
KZ	4,140	28,903	-7.453	24.05	-36.509	-4.956	-1.097	0.645	2.453

Table 2.1: Summary of Innovation and Institutional Ownership

This table reports the sample statistics for the 2000–2010 period. Panel A reports the means of innovation and institutional ownership sample data by country. *Firms* is the number of firms in each sample country. *Firms-Years* is the number of firm-year observations. *Patent* is the total number of patent applications filed by each firm in each year. *Citation* is the total number of citations received by each firm's patents in each year. *FIO* and *DIO* are foreign institutional ownership and domestic institutional ownership, respectively. Panel B contains the summary statistics of firm variables. Details of variable definitions are in Appendix 2.

Panel A: Firm Innovation and Institutional Ownership by Country

Country	Type of Economy	Firms	Firm-Years	Innovation		Inst. Own.	
				Patent	*Citation*	*FIO*	*DIO*
Australia	DEV	120	730	0.886	2.224	4.220	1.347
Austria	DEV	29	205	1.676	2.172	9.125	1.860
Belgium	DEV	22	163	7.948	11.125	11.241	3.375
Brazil	EMG	46	313	1.324	2.247	7.972	0.373
Canada	DEV	246	1,579	1.849	3.653	9.589	13.996
Denmark	DEV	27	212	2.158	2.771	6.517	11.123
Finland	DEV	49	399	2.003	4.187	11.406	8.998
France	DEV	210	1,417	2.675	2.936	6.530	4.364
Germany	DEV	235	1,644	4.015	6.333	7.299	4.616
Greece	EMG	14	66	0.242	0.098	1.834	0.570
Hong Kong	DEV	13	101	0.426	0.391	7.399	1.205
India	EMG	182	1,073	2.600	4.746	3.681	3.127
Israel	EMG	62	343	1.708	3.818	18.997	1.029
Italy	DEV	66	461	3.026	4.134	7.566	2.605
Japan	DEV	1,239	10,527	5.508	8.628	2.424	2.292
Korea	EMG	572	3,021	3.493	6.749	2.863	0.107
Netherlands	DEV	20	160	7.443	11.773	18.668	4.631
Norway	DEV	47	267	1.027	0.930	8.722	10.223
New Zealand	DEV	12	74	2.281	4.420	1.155	0.524
Singapore	DEV	36	291	1.218	1.322	5.460	1.083
Spain	DEV	23	191	0.267	0.193	6.796	4.687
South Africa	EMG	16	120	0.803	0.508	8.429	4.197
Sweden	DEV	85	596	2.851	5.116	6.856	12.721
Switzerland	DEV	39	313	3.989	6.669	9.506	6.135
Taiwan	EMG	583	3,606	4.762	6.728	2.107	0.286
United Kingdom	DEV	147	1,031	2.021	3.621	4.641	19.241
Developed		2,665	20,361	4.094	6.434	4.862	5.071
Emerging		1,475	8,542	3.702	6.067	3.552	0.669
All economies		4,140	28,903	3.988	6.349	4.474	3.769

2.4.2 Baseline Regression Results

This subsection presents the baseline regression results examining the relation between foreign institutions and firm innovation. Table 2.2 shows the regression results for equation (2.1). Panel A (B) reports the coefficient estimates where the dependent variable is the natural logarithm of one plus the number of patents (citations).

As can be shown, the coefficient estimates of FIO are positive and highly significant at the 1% level across all specifications, suggesting that greater foreign institutional ownership is associated with more innovation at the firm level. A coefficient estimate of 0.009, for example, suggests that a one standard deviation increase in foreign institutional ownership is associated with 7.81% more patents. This seems a result of both economic and statistical significance. In columns 2 and 4, where domestic institutional ownership is added to the regressions, the coefficient on FIO remains positive and highly significant. These empirical results appear to support the second hypothesis rather than the first: foreign institutions enhance firm innovation.

With regard to other control variables, the coefficient estimates are largely consistent with findings in earlier work. Firms with higher R&D and capital expenditures are associated with more patents and citations. Firm size, as measured by firm sales to follow Hall and Ziedonis's (2001) study on patenting activity in the U.S., is positively related to innovation. Firms with more growth opportunities have more patents and citations, consistent with Hall, Jaffe, and Trajtenberg (2005). More highly levered firms are associated with less innovation, perhaps because high leverage, which constrains managerial flexibility (Graham and Harvey, 2001), allows lower tolerance for experimentation and creativity. Financial constraints are negatively related to innovation, consistent with earlier work (see Hall and Lerner, 2010, for a survey). Firm age, however, is unrelated to innovation, as is industry concentration. Finally, the coefficient estimate of DIO is negative and significant at either the 5% or 10% levels. Ferreira and Matos (2008) find that while foreign institutional investors are active, effective monitors of the non-U.S. firms in which they invest, domestic institutional investors remain passive monitors due to the current or prospective business relationships which they have with investee firms. This lack of monitoring incentives among domestic institutions provides firm managers with better opportunities to shirt, i.e., prefer "quite lives", suggesting that firm managers tend to avoid undertaking high-risk, high-payoff innovation projects, which by nature require high levels of effort (Bertrand and Mullainathan, 2003; Hart, 1983).

Overall, this subsection shows the baseline results that document a positive relation between foreign institutional ownership and firm innovation, consistent with the second hypothesis that foreign institutional investors enhance firm innovation.

Table 2.2: Firm Innovation and Institutional Ownership – Baseline Regressions

This table reports the pooled OLS regressions of firm innovation on institutional ownership. The main independent variable is foreign institutional ownership (FIO). All regressions include a full set of controls as described in Appendix 2. Panel A presents the results where the dependent variable is the natural logarithm of one plus the number of patents ($Ln(1 + Patent)$). Panel B presents the results where the dependent variable is the natural logarithm of one plus the number of citations received by patents ($Ln(1 + Citation)$). All explanatory variables are lagged by one year. All regressions include a full set of industry, country, and year dummies. Robust standard errors are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Panel A: $Ln(1 + Patent)$		**Panel B:** $Ln(1 + Citation)$	
	1	2	3	4
FIO	0.009***	0.010***	0.013***	0.014***
	(0.002)	(0.002)	(0.002)	(0.003)
DIO		-0.006**		-0.007*
		(0.003)		(0.003)
$Ln(AGE)$	0.048	0.046	0.053	0.051
	(0.088)	(0.088)	(0.088)	(0.089)
HHI	-0.072	-0.063	-0.135	-0.125
	(0.171)	(0.170)	(0.246)	(0.246)
$HHISQ$	0.133	0.119	0.186	0.170
	(0.181)	(0.180)	(0.213)	(0.212)
RD	1.552**	1.574***	1.836**	1.861**
	(0.562)	(0.556)	(0.743)	(0.737)
$CAEX$	1.370***	1.365***	1.861***	1.854***
	(0.308)	(0.310)	(0.363)	(0.364)
PPE	-0.232*	-0.234*	-0.202	-0.204
	(0.131)	(0.130)	(0.151)	(0.149)
LEV	-0.247	-0.252	-0.325**	-0.330**
	(0.148)	(0.149)	(0.126)	(0.128)
ROA	-0.240	-0.202	-0.461**	-0.417**
	(0.180)	(0.187)	(0.175)	(0.177)
$Ln(SALE)$	0.158***	0.160***	0.185***	0.187***
	(0.020)	(0.019)	(0.027)	(0.025)
Q	0.039***	0.038***	0.060***	0.059***
	(0.010)	(0.010)	(0.012)	(0.013)
KZ	-0.001**	-0.001**	-0.002***	-0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Adj. R^2	0.150	0.151	0.142	0.143
Obs.	28,903	28,903	28,903	28,903

2.5 Robustness Checks

Despite the evidence in support of a positive effect of foreign institutional ownership on firm innovation as reported in Subsection 2.4.2, there are several concerns that need to be addressed. This subsection presents two robustness checks on the baseline results.

2.5.1 Subsampling

It can be argued that the baseline regression results documented in Section 2.4.2 are driven by Japanese firms because they dominate in the study sample. To address this concern, equation 2.1 is re-estimated after excluding Japanese firms from the same sample as used in the baseline regressions.

Table 2.3 present the regressions based on a subsample of non-Japanese firms. Column 1 presents the results for the regression in which the dependent variable is $Ln(1 + Patent)$ and column 3 for the regression in which the dependent variable is $Ln(1 + Citation)$.

Table 2.3 shows that excluding Japanese firms does not qualitatively alter the positive relation between foreign institutional ownership and innovation. The coefficient estimate of FIO remains positive and highly significant at the 1% level in both regressions. A one standard deviation increase in foreign institutional ownership is associated with a 9.54% increase in patent counts. For citation counts, it is about 13.01%. Hence, subsampling does not seem to change qualitatively the economic and statistical significance of the positive effect of foreign institutional ownership on firm innovation.

2.5.2 Firm Fixed Effects Estimation

Another major concern with the baseline results is the omitted variable problem. To partially address this issue, firm fixed effects are included in the regressions to absorb time-invariant unobservable firm characteristics that affect both foreign institutional ownership and firm innovation.

Again, the coefficient estimates of FIO remain positive and highly significant at the 1% level, as shown in columns 2 and 4 in Table 2.3. A one standard deviation increase in foreign institutional ownership is now associated with a 3.47% increase in patent counts and a 4.34% increase in citation counts. The consistency of the fixed effect results with the baseline regressions confirms that there is robust evidence on the positive effect of foreign institutional ownership on firm innovation.

Table 2.3: Robustness Checks – Subsampling and Firm Fixed Effects Regressions

This table reports the results of alternative regression of firm innovation on foreign institutional ownership. The main independent variable is foreign institutional ownership (FIO). All regressions include a full set of controls as described in Appendix 2. Panel A reports the results where the dependent variable is the natural logarithm of one plus the number of patents ($Ln(1 + Patent)$). Panel B presents the results where the dependent variable is the natural logarithm of one plus the number of citations received by patents ($Ln(1 + Citation)$). Columns 1 and 3 present the results for a subsample of non-Japanese firms with controls for year, industry and country dummies and robust standard errors reported in parentheses. Columns 2 and 4 report the firm fixed effects regressions with year dummies and standard errors clustered by firm. All explanatory variables are lagged by one year. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Panel A: $Ln(1 + Patent)$		**Panel B:** $Ln(1 + Citation)$	
	Ex. Japan	Firm FE	Ex. Japan	Firm FE
	1	2	3	4
FIO	0.011***	0.004***	0.015***	0.005**
	(0.003)	(0.001)	(0.003)	(0.002)
DIO	-0.008*	-0.002*	-0.009*	-0.001
	(0.004)	(0.001)	(0.004)	(0.001)
$Ln(AGE)$	-0.089***	0.098***	-0.087***	0.137***
	(0.020)	(0.021)	(0.021)	(0.031)
HHI	-0.148	-0.146	-0.319	0.267
	(0.194)	(0.152)	(0.213)	(0.223)
$HHISQ$	0.192	0.093	0.332	-0.075
	(0.202)	(0.134)	(0.195)	(0.198)
RD	1.054***	-0.010	1.162**	-0.288*
	(0.320)	(0.114)	(0.437)	(0.168)
$CAEX$	0.982***	0.441***	1.419***	0.567***
	(0.308)	(0.097)	(0.348)	(0.143)
PPE	-0.069	-0.107*	-0.040	-0.124
	(0.096)	(0.060)	(0.127)	(0.088)
LEV	-0.445***	-0.125***	-0.473***	-0.190***
	(0.108)	(0.040)	(0.118)	(0.059)
ROA	-0.104	-0.060	-0.354**	-0.202**
	(0.154)	(0.062)	(0.133)	(0.091)
$Ln(SALE)$	0.139***	0.108***	0.159***	0.116***
	(0.019)	(0.009)	(0.026)	(0.014)
Q	0.032**	0.009**	0.055***	0.005
	(0.012)	(0.004)	(0.016)	(0.006)
KZ	-0.001*	-0.001***	-0.002**	-0.001***
	(0.000)	(0.000)	(0.001)	(0.000)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes
Industry fixed effects	Yes	No	Yes	No
Country fixed effects	Yes	No	Yes	No
Adj. R^2	0.144	0.769	0.123	0.651
Obs.	18,376	28,903	18,376	28,903

2.6 Identification

While the regression results so far provide support for a positive relation between foreign institutional ownership and firm innovation that is robust to the use of a subsample of non-Japanese firms, as well as firm fixed effects that absorb time-invariant unobservable firm heterogeneity, they are still subject to endogeneity concerns. One concern is that time-varying unobservable firm characteristics omitted from the regression could bias the inference. Another one is the problem of reverse causality in which firms with high innovation potential could attract foreign institutional investors, suggesting that the direction of causality goes from innovation to foreign institutional ownership. This subsection establishes causality by using two different identification strategies: (i) a DiD approach and (ii) an instrumental variable approach.

2.6.1 Difference-in-Differences Approach

In the first identification strategy, the DiD approach is used to establish causality regarding the effect of foreign institutional ownership on firm innovation. This methodology compares the innovation output of treatment firms with that of control firms before and after a policy change that causes an exogenous shock to foreign institutional ownership. To create plausibly exogenous variation in foreign institutional ownership, this study takes advantage of a quasi-natural experiment—the passage of the U.S. Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA). The JGTRRA substantially lowered dividend tax rates (from 38.6% to 15%) not only for U.S. firms but also for foreign firms domiciled in countries that have tax treaties with the U.S. Dividends from foreign firms in non-treaty countries, however, remain taxable at the ordinary personal income tax rate after the passage of the JGTRRA (e.g., 35% for the top income tax bracket). Therefore, non-treaty countries, which include such sample countries as Brazil, Hong Kong, and Singapore, are ineligible for this favorable tax treatment. [4] After the JGTRRA enactment, dividend paying stocks in treaty countries have become relatively more attractive to U.S. institutional investors than those in non-treaty countries. Desai and Dharmapala (2011) find that following the passage of the JGTRRA, many U.S. institutions reallocated their portfolio holdings to dividend paying stocks in treaty countries.

The passage of the JGTRRA appears to be a good candidate for a quasi-natural experiment that causes plausibly exogenous variation in foreign institutional ownership for non-U.S. firms in the study sample. Since the JGTRRA was designed to lower dividend tax rates for both U.S. firms and non-U.S. firms domiciled in foreign countries that have tax treaties with the U.S., which affects U.S. foreign institutional ownership, it is unlikely to directly affect the innovation output of non-U.S. firms. Changes in foreign institutional ownership surrounding the passage of the JGTRRA exhibit variation in the cross-section of firms in treaty and non-treaty countries. As for the reverse causality concern, it is unlikely that changes in future innovation affect changes in foreign institutional ownership brought about by the passage of the JGTRRA. Therefore, examining the change in innovation output following the change in U.S. institutional ownership due to the passage of the JGTRRA provides a quasi-natural experiment to determine whether the effect of foreign institutional ownership on firm innovation is causal. The DiD approach is used to compare the innovation output of the treatment firms with that of the control firms three years before (2000–2002) and three years after (2004–2006) the JGTRRA.

Two conditions are to be satisfied in selecting the treatment firms. First, they must be domiciled in treaty countries and pay dividends in the year prior to the passage

[4]The list of non-treaty countries also includes Argentina, Chile, Colombia, Jordan, Malaysia, Peru, and Sri Lanka.

in 2003 of the JGTRRA. Second, they must experience a positive change in U.S. institutional ownership (FIO_{US}) around the tax cut event (from the year before to the year after the event, i.e., 2002–2004). The purpose of these requirements is to ensure that an increase in U.S. foreign institutional ownership in a treatment firm is driven mostly by this tax policy change. An increase in U.S. institutional ownership can possibly occur after 2004, but the design of the DiD test is to compare the innovation output of the three-year pre-treatment period (2000–2002) with that of the three-year post-treatment period (2004–2006), so that this study can focus on firms that receive the treatment surrounding the policy change (2002–2004). These filters result in a treatment group of 920 firms. To form the control group, it is required that firms be domiciled in non-treaty countries and pay dividends in the year prior to the passage of the JGTRRA or domiciled in treaty countries but do not pay dividends in the year prior to the passage of the JGTRRA.

To match treatment firms with control firms, this study uses the nearest neighbor propensity score matching algorithm. Specifically, a probit model is estimated for observations in the year immediately preceding the passage of the JGTRRA. The dependent variable equals one if the firm-year belongs to the treatment group and zero otherwise. The probit regression uses the same set of control variables as those in the baseline OLS regressions, including industry and country dummies. Because the JGTRRA directly affects U.S. institutional investors, foreign institutional ownership (FIO) is separated into U.S. foreign institutional ownership (FIO_{US}) and non-U.S. foreign institutional ownership (FIO_{NonUS}).

To ensure that the important identifying assumption of the DiD approach—the parallel trend assumption—two innovation growth variables (i.e., the growth in the number of patents, $Growth_{Patent}$, and the growth in the number of citations, $Growth_{Citation}$) are added to the probit regression, both of which are computed over the three-year period before the passage of the JGTRRA. This assumption states that in the absence of a policy treatment (the passage of the JGTRRA in this study), the observed DiD estimator is zero. This assumption does not require that the level of innovation variables be the same between the treatment and control firms over the two sub-periods before and after the passage of the JGTRRA, because these distinctions are differenced out in the estimation; instead, it requires pre-JGTRRA trends in innovation variables be similar for both the treatment and control groups.

Column 1 in Panel A of Table 2.4 (labeled as "Pre-Match") reports the probit regression results. It shows that this specification captures a significant amount of variation of the choice variable, as suggested by a pseudo-R^2 of 24.4% and a p-value well below 0.001 from the chi-square test of the overall model fitness. The predicted probabilities, or propensity scores, which are extracted from this estimated probit regression, are then used in applying the nearest-neighbor propensity score matching algorithm. Each firm in the treatment group is matched with a firm in the control group for which the distance between the two firms' propensity scores is the smallest. If a firm from the treatment group is matched with more than one control firm, the pair for which the distance between the two firms' propensity scores is the smallest is retained. The resulting matched sample has 424 unique pairs of matched firms. [5]

Since the validity of the DiD critically depends on the parallel trend assumption, several tests must be conducted to verify that the assumption is not violated. In the first test, the probit model restricted to the matched sample is re-estimated, the results of which are reported in column 2 of Panel A in Table 2.4 ("Post-Match"). As shown clearly, none of the independent variables, including unreported industry and country dummies, is statistically significant. In particular, the coefficient estimates of the pre-shock innovation growth variables ($Growth_{Patent}$ and $Growth_{Citation}$) are

[5] Following Fang, Tian, and Tice (2014), this study uses the matching procedure without replacement to improve the matching precision at the expense of a loss of sample observations. In so doing, the power in the DiD tests is sacrificed to obtain precise matches with comparable firms.

both statistically insignificant. This implies that there are no observable different trends in innovation outcomes between the two groups of firms pre-JGTRRA, suggesting that the parallel trend assumption is satisfied. In addition, the pseudo-R^2 drops significantly from 22.4% pre-matching to 2.6% post-matching. A chi-square test for the overall model fitness shows that the null hypothesis that all of the coefficient estimates of the independent variables are zero cannot be rejected (with a p-value of 0.987).

In the second test, the difference in the propensity scores between the treatment firms and the matched control firms are examined. Panel B in Table 2.4 shows that the difference is negligible, because the maximum distance between the two matched firms' propensity scores is only 0.002 and the 95th percentile of the distance is only 0.001.

In the third test, the univariate comparisons between the treatment firms' and the control firms' pre-JGTRRA characteristics are made and reported in Panel C of Table 2.4 together with their corresponding t-statistics. None of the post-matching differences is statistically significant. Overall, these diagnostic tests suggest that the propensity score matching process removes meaningful observable differences in observable covariates between the treatment firms and the control firms. These tests suggest that the changes in innovation are likely to be caused only by the exogenous change in foreign institutional ownership due to the passage of the JGTRRA.

Panel D in Table 2.4 presents the DiD estimators. Column 1 reports the average difference in the number of patents ($Patent$), as well as the number of citations received by patents ($Citation$) for the treatment group. The average difference in the number of patents (citations) for the treatment group is calculated by first subtracting the average number of patents (citations) over the three-year period preceding the JGTRRA enactment from the average number of patents (citations) over the three-year period post-JGTRRA for each treatment firm, and then averaging these differences over the treatment group. The average difference in the number of patents and citations for the control firms is computed in a similar manner and presented in column 2. The DiD estimators are shown in columns 3–4, together with their corresponding t-statistics that test the null hypothesis that the DiD estimators are zero.

Two main findings deserve remarks. First, the innovation output of the treatment firms increase post-JGTRRA while that of the control firms decrease—a finding which is consistent with the baseline results that greater foreign institution ownership is associated with more innovation. Second, the increase in innovation output from three years before the passage of the JGTRRA to three years after is significantly larger for the treatment group than for the control group, because the DiD estimators of both *Patent* and *Citation* are positive and highly significant at the 1% level. The magnitude of the DiD estimator of *Patent* suggests that, on average, an exogenous shock to U.S. foreign institutional ownership due to the passage of the JGTRRA brings about an increase of 2.45 more patents per year for the treatment firms. Similarly, the treatment firms have 4.21 more citations per patent per year. Overall, these results suggest that an exogenous increase in U.S. foreign institutional ownership due to the passage of the JGTRRA leads to higher innovation output.

These trends can be visually examined in Figure 2.1 and Figure 2.2. Figure 2.1 shows the number of patents for the treatment and control firms over a seven-year period surrounding the passage of the JGTRRA tax cut. Figure 2.2 depicts the number of citations for these groups over the same period. As shown, the two lines representing the number of patents (citations) for the treatment firms and for the control firms have trended closely in parallel in the years leading up to the passage of the JGTRRA, which suggests that the parallel trend assumption is satisfied. After the JGTRRA enactment, however, the line representing the treatment firms began to trend upward and above the line representing the control firms, indicating that the treatment firms experiencing an exogenous increase in U.S. foreign institutional ownership increase their innovation output.

While the JGTRRA generates an exogenous shock to foreign institutional ownership, it is still possible that the results are driven by reverse causality due to the concern that expected changes in innovation could trigger the passage of the JGTRRA. To address this concern, this study follows the methodology of Bertrand and Mullainathan (2003) to examine the dynamics of innovation output surrounding the passage of the JGTRRA. Specifically, firm-year observations for both the treatment and control firms for a seven-year window centered in 2003 are retained for use in the following regression:

$$\begin{aligned} Innovation &= \alpha + \beta_1(Treat \times Before_{-1}) + \beta_2(Treat \times Current_0) \\ &+\beta_3(Treat \times After_1) + \beta_4(Treat \times After_{2,3}) + \beta_5 Treat \\ &+\beta_6 Before_{-1} + \beta_7 Current_0 + \beta_8 After_1 + \beta_9 After_{2,3} + \varepsilon. \end{aligned} \quad (2.2)$$

The dependent variable ($Innovation$) is either the number of patents in a given year ($Patent$) or the number of citations per patent ($Citation$). $Treat$ is a dummy variable that equals one for the treatment firms and zero for the control firms. $Before_{-1}$ is a dummy variable that equals one if a firm-year observation is from the year before the passage of the JGTRRA and zero otherwise. $Current_0$ is a dummy variable that equals one if a firm-year observation is from the tax cut year (2003) and zero otherwise. $After_1$ is a dummy variable that equals one if a firm-year observation is from the year immediately after the tax cut and zero otherwise. $After_{2,3}$ is a dummy variable that equals one if a firm-year observation is from two or three years after the passage of the JGTRRA and zero otherwise.

Panel E of Table 2.4 reports the regression results for equation (2.2), where the key coefficient estimates are $\beta_1, \beta_2, \beta_3$, and β_4. Both columns 1–2 show statistically insignificant coefficient estimates of β_1 and β_2, which implies that the parallel trend assumption of the DiD approach is not violated and there is no difference in pre-JGTRRA trend in innovation output between treatment and control firms. However, the coefficient estimates of β_3 and β_4 are statistically significant, which suggests that, compared with control firms, treatment firms generate a larger number of patents and citations in the years following the passage of the JGTRRA. These results are thus consistent with Figure 2.1 and Figure 2.2.

Overall, this subsection presents the results of a DiD approach based on the passage of the JGTRRA as a natural quasi-experiment that generates an exogenous shock to U.S. foreign institutional ownership of dividend paying stocks domiciled in treaty countries. The DiD results suggest that the positive effect of foreign institutional ownership on firm innovation is causal, which reinforces earlier reported evidence for the second hypothesis.

Table 2.4: Difference-in-Differences Analysis

This table reports the diagnostics and results of the DiD tests on how exogenous shocks to foreign institutional ownership due to the passage of the 2003 JGTRRA tax cut event affect firm innovation. Sample selection begins with all firms with non-missing variables and non-missing observation outcomes in the pre-tax cut year (2002) and the post-tax cut year (2004). Treatment firms must pay dividends in the pre-tax cut year, be domiciled in treaty countries, and have a positive change in institutional ownership around the event. Control firms must be domiciled in non-treaty countries and pay dividends in the pre-tax cut year, or be domiciled in treaty countries but do not pay dividend in the pre-tax cut year. Control firms are then matched to the treatment firms based on one-to-one nearest neighbor propensity score matching without replacement, on a vector of observable characteristics including the same variables as used in the baseline regression, and innovation growth variables $Growth_{Patent}$ and $Growth_{Citation}$ over three years before the tax cut. Panel A reports the results from the probit model used in estimating the propensity scores for the treatment and control groups in the pre-tax cut year. The dependent variable is one if the firm belongs to the treatment group and zero otherwise. The coefficient estimates are reported and their robust standard errors are displayed in parentheses below. Panel B reports the distribution of estimated propensity scores for the treatment and control firms and the difference in the estimated propensity scores post-matching. Panel C reports the univariate comparisons between treatment and control groups and their corresponding t-statistics. Panel D reports the DiD estimators. *Patent* is the average of the number of patents in the three-year window before and after the event year 2003. *Citation* is the average of the number of citations per patent in the three-year window before and after the event year 2003. Panel E reports the results that estimate the innovation dynamics of treatment and control firms surrounding the passage of the JGTRRA tax cut as follows:

$$\begin{aligned} Innovation &= \alpha + \beta_1(Treat \times Before_{-1}) + \beta_2(Treat \times Current_0) \\ &\quad + \beta_3(Treat \times After_1) + \beta_4(Treat \times After_{2,3}) + \beta_5 Treat \\ &\quad + \beta_6 Before_{-1} + \beta_7 Current_0 + \beta_8 After_1 + \beta_9 After_{2,3} + \varepsilon \end{aligned}$$

The dependent variable ($Innovation$) is either the number of patents in a given year ($Patent$) or number of citations per patent in a given year ($Citation$). $Treat$ a dummy that equals one for treatment firms and zero for control firms. $Before_{-1}$ is a dummy that equals one if a firm-year observation is from the year before the tax cut (year-1) and zero otherwise. $Current_0$ is a dummy that equals one if a firm-year observation is from the tax cut year (year 0) and zero otherwise. $After_1$ is a dummy that equals one if a firm-year observation is from the year immediately after the passage of the JGTRRA tax cut (year 1) and zero otherwise. $After_{2,3}$ is a dummy that equals one if a firm-year observation is from two or three years after the passage of the JGTRRA (year 2 and 3) and zero otherwise. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Pre-Match Propensity Score Regression and Post-Match Diagnostic Regression		
	Pre-Match	Post-Match
	1	2
FIO_{US}	-0.032***	-0.007
	(0.009)	(0.013)
FIO_{NonUS}	-0.014	-0.009
	(0.011)	(0.019)
DIO	0.028***	-0.012
	(0.006)	(0.011)
$Ln(AGE)$	0.054	-0.019
	(0.049)	(0.075)
HHI	-0.314	0.504
	(0.509)	(0.768)
$HHISQ$	0.183	-0.453
	(0.477)	(0.709)
RD	-0.576	1.658
	(0.994)	(1.589)
$CAEX$	1.949**	0.233
	(0.800)	(1.188)
PPE	-0.591**	-0.271
	(0.253)	(0.373)
LEV	-1.200***	-0.131
	(0.195)	(0.293)
ROA	3.367***	-1.585
	(0.506)	(0.982)
$Ln(SALE)$	-0.001	0.002
	(0.002)	(0.003)
Q	0.355***	-0.005
	-0.025	(0.038)
KZ	-0.025	0.042
	(0.039)	(0.066)
$Growth_{Patent}$	0.027	-0.036
	(0.036)	(0.057)
$Growth_{Citation}$	0.023	0.046
	(0.019)	(0.033)
Industry fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
p-value of χ^2	< 0.000	0.987
Pseudo R^2	0.244	0.026
Obs.	2,311	846

Panel B: Estimated Propensity Score Distribution										
Propensity Score	**N**	**Mean**	**SD**	**Min**	**P5**	**P25**	**P50**	**P75**	**P95**	**Max**
Treatment	424	0.479	0.200	0.013	0.135	0.344	0.479	0.626	0.814	0.092
Control	424	0.479	0.200	0.013	0.134	0.344	0.479	0.626	0.814	0.092
Difference	424	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002

Panel C: Differences in Observables				
Variable	**Treatment**	**Control**	**Differences**	***t*-statistics**
FIO_{US}	1.523	1.791	-0.268	-0.880
FIO_{NonUS}	1.687	2.045	-0.358	-1.430
DIO	3.281	3.090	0.191	0.390
$Ln(AGE)$	2.579	2.598	-0.019	-0.360
HHI	0.255	0.250	0.005	0.300
$HHISQ$	0.138	0.127	0.010	0.610
RD	0.018	0.021	-0.004	-1.290
$CAEX$	0.052	0.052	-0.001	-0.290
PPE	0.318	0.301	0.017	1.510
LEV	0.236	0.218	0.018	1.590
ROA	0.092	0.094	-0.001	-0.330
$Ln(SALE)$	6.117	6.140	-0.023	-0.220
Q	1.203	1.279	-0.077	-1.290
KZ	-3.472	-3.801	0.330	0.340
$Growth_{Patent}$	0.303	0.309	-0.006	-0.090
$Growth_{Citation}$	0.452	0.364	0.088	0.720

Panel D: Difference-in-Differences Test				
	Treatment Group	Control Group	Treatment–Control	*t*-statistics for
	After–Before	After–Before	DiD Estimator	DiD Estimator
	1	2	3	4
Patent	1.021	-1.428	2.449***	3.224
	(0.417)	(0.652)	(0.759)	
Citation	2.296	-1.915	4.210***	3.066
	(0.731)	(1.097)	(1.373)	

Panel E: Difference-in-Differences Dynamic Regression		
	Patent	*Citation*
	1	2
$Treat \times Before_{-1}$	0.121	0.442
	(0.624)	(1.121)
$Treat \times Current_0$	0.884	1.643
	(0.624)	(1.121)
$Treat \times After_1$	1.306**	2.122*
	(0.624)	(1.121)
$Treat \times After_{2,3}$	1.290**	2.785***
	(0.510)	(0.915)
$Treat$	-0.592	-1.642**
	(0.360)	(0.647)
$Before_{-1}$	0.482	0.449
	(0.441)	(0.793)
$Current_0$	-0.553	-1.194
	(0.441)	(0.793)
$After_1$	-0.488	-1.307*
	(0.441)	(0.793)
$After_{2,3}$	-0.547	-1.293**
	(0.360)	(0.647)
Adj. R^2	0.002	0.002
Obs.	5,936	5,936

Figure 2.1: Number of Patents Surrounding the Passage of the 2003 JGTRRA Tax Cut

This figure shows the average innovation captured by the mean number of patents for control and treatment firms from three years before to three years after the passage of the JGTRRA. The event year is denoted as Year 0 (2003). The sample contains 424 treatment firms and 424 unique control firms matched based on the procedures described in Table 2.4.

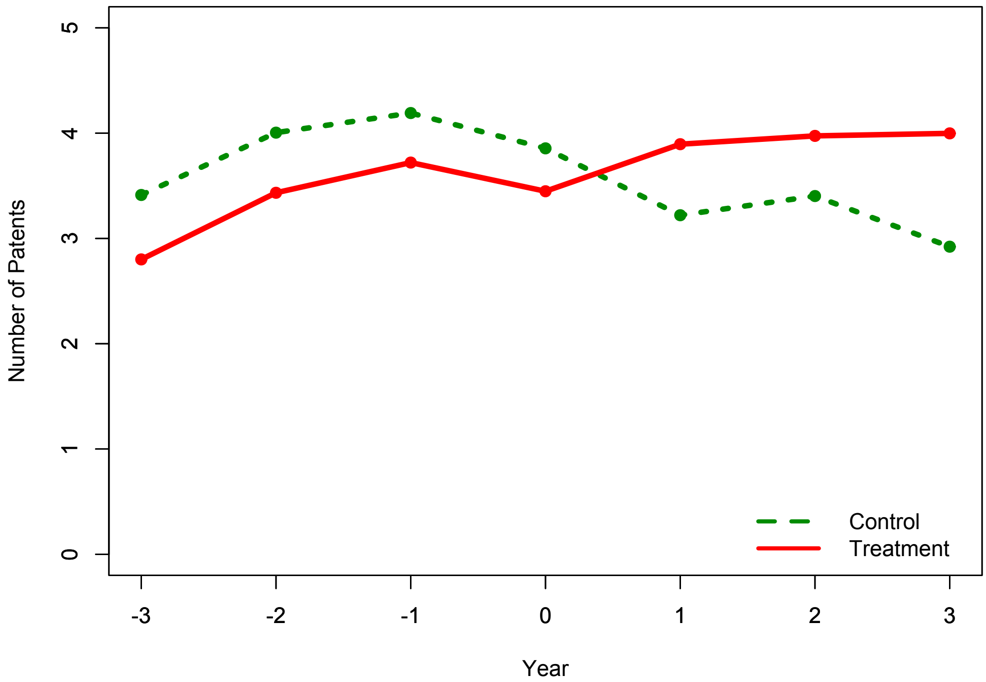
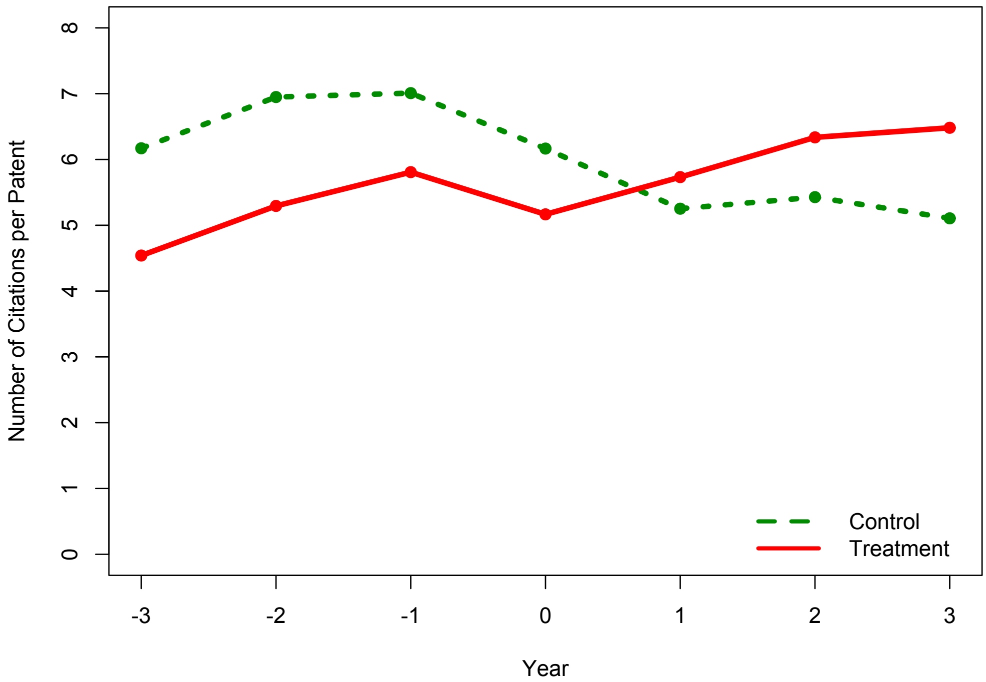


Figure 2.2: Number of Citations per Patent Surrounding the Passage of the 2003 JGTRRA Tax Cut

This figure shows the average innovation captured by the mean number of citations for control and treatment firms from three years before to three years after the passage of the 2003 JGTRRA. The event year is denoted as year 0 (2003). The sample contains 424 treatment firms and 424 unique control firms matched based on the procedures described in Table 2.4.



2.6.2 Instrumental Variable Approach

In the second identification strategy, this study constructs an instrument for foreign institutional ownership and uses the 2SLS approach to further tease out the causal effect of foreign institutional ownership on firm innovation. An ideal instrument should capture the variation in foreign institutional ownership that is exogenous to firms' innovation output. The instrument should be correlated with foreign institutional ownership (the relevance condition) but uncorrelated with firm innovation except through its effect on foreign institutional ownership (the exclusion restriction). Following earlier work such as Ferreira and Matos (2008) and Aggarwal et al. (2011), this study uses the membership in the MSCI All Country World Index (MSCI ACWI) as an instrument for foreign institutional ownership. Specifically, the instrument is defined as a dummy variable ($MSCI$) that equals one if a firm is a member of the MSCI ACWI and zero otherwise.

As a free float-adjusted market capitalization weighted index that is designed to measure the global equity market performance of developed and emerging markets, MSCI ACWI consists of 45 country indices (24 developed and 21 emerging markets). Launched in 1987, this index covers approximately 85% of the global investable equity opportunity set.[6] In a study of global institutional investors' preferences for stocks, Ferreira and Matos (2008) find that both the U.S. and other foreign institutional investors show a strong bias for companies in the MSCI ACWI. Leuz, Lins, and Warnock (2010) find that the MSCI membership increases the probability that a firm will attract foreign capital. Therefore, foreign institutional ownership appears to be positively related to the inclusion in the MSCI ACWI, which is required to satisfy the relevance condition. In addition, there appears to be no plausible reason to believe that an inclusion in the MSCI ACWI is related to firm innovation

[6] See a detailed discussion at www.msci.com

in any way other than through its impact on foreign institutional ownership. Thus this instrument reasonably satisfies the exclusion restriction and helps identify the direction of causality.

To check the relevance of the instrument, column 1 of Table 2.5 shows the first-stage regression with FIO as the dependent variable, the instrument as the main independent variable, and the same set of independent variables as used in the baseline regressions. The coefficient estimate of $MSCI$ is positive and highly significant at the 1% level, which suggests that foreign institutional ownership is positively associated with the MSCI ACWI membership. Because the p-value of the F-test of instruments shown at the bottom of the table is very close to zero (< 0.001), the instrument is highly correlated with FIO. Based on the rule of thumb with one instrument for one endogenous variable, the null hypothesis that the instrument is weak is rejected. Therefore, the coefficient estimates and their corresponding standard errors reported in the second stage are likely to be unbiased and inferences based on them are reasonably valid.

In columns 2–3 in Table 2.5, the fitted (instrumented) values of FIO are used as the main independent variable in the second-stage regressions, in which the dependent variables are the innovation variables: $Ln(1 + Patent)$ and $Ln(1 + Citation)$. As shown clearly, the coefficient estimates of the instrumented (FIO) continue to be positive and significant at the 1% level, reinforcing the baseline results.

To gauge the direction and magnitude of the bias due to the endogeneity in foreign institutional ownership, the OLS results in Table 2.2 are compared with the 2SLS results in Table 2.5. It is worth noting that the magnitudes of the 2SLS coefficient estimates (0.033 for $Ln(1 + Patent)$ and 0.040 for $Ln(1 + Citation)$) are considerably larger than those of the OLS estimates (0.010 for $Ln(1 + Patent)$ and 0.014 for $Ln(1 + Citation)$) although the coefficient estimates from both approaches are positive and statistically significant, which suggests that OLS regressions bias the coefficient estimates of FIO downward due to the endogeneity of foreign institutional ownership. This finding suggests that some omitted variables simultaneously make firms more innovative and less attractive to foreign institutional investors. A firm's technology development nature, if time-varying within a firm, could be an example of such omitted variables. For example, a firm that is heavily involved in the early-stage development of a new technology, which requires a lot of local knowledge, may be appear too "opaque" to foreign institutional investors and therefore attract less holdings from foreign institutional investors. Meanwhile, heavy investment in early-stage technologies may result in more patents and citations. This negative relation between foreign institutional ownership and firm innovation caused by the omitted variable is the main driving force that biases the coefficient estimates of foreign institutional ownership downward. Once the instrument is used to clean up the correlation between foreign institutional ownership and the residuals (the firm's unobservable characteristics) in equation 2.1, the endogeneity of foreign institutional ownership is removed and the coefficient estimates increase (i.e., become more positive).

In summary, the identification strategy based on an instrument variable approach in this subsection suggests a positive, causal effect of foreign institutional ownership on firm innovation, which is consistent with the second hypothesis that foreign institutional investors enhance firm innovation.

Table 2.5: Instrumental Variable Estimation

This table presents the two-stage least squares regressions of firm innovation on institutional ownership. The main independent variable is foreign institutional ownership (FIO). All regressions include a full set of controls as described in Appendix 2. The $MSCI$ dummy for membership in the MSCI All Country World Index is used as the instrumental variable for foreign institutional ownership. All regressions control for year, industry, and country dummies. Robust standard errors are reported in parentheses. All explanatory variables are lagged by one year. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	First-Stage	Second-Stage	
	FIO	$Ln(1 + Patent)$	$Ln(1 + Citation)$
	1	2	3
$MSCI$	2.584***		
	(0.100)		
$Predicted\ FIO$		0.033***	0.040***
		(0.012)	(0.015)
DIO	0.087***	-0.006***	-0.009***
	(0.004)	(0.001)	(0.002)
$Ln(AGE)$	-0.168***	0.047***	0.057***
	(0.039)	(0.011)	(0.013)
HHI	0.761**	-0.071	-0.163
	(0.371)	(0.101)	(0.122)
$HHISQ$	-0.339	0.129	0.192*
	(0.352)	(0.096)	(0.115)
RD	3.993***	1.586***	1.758***
	(0.433)	(0.114)	(0.150)
$CAEX$	4.398***	1.370***	1.702***
	(0.511)	(0.140)	(0.177)
PPE	0.276	-0.232***	-0.207***
	(0.179)	(0.043)	(0.054)
LEV	-2.969***	-0.259***	-0.250***
	(0.143)	(0.052)	(0.062)
ROA	-0.895***	-0.208***	-0.384***
	(0.256)	(0.062)	(0.078)
$Ln(SALE)$	1.240***	0.163***	0.147***
	(0.018)	(0.018)	(0.022)
Q	0.452***	0.039***	0.043***
	(0.019)	(0.008)	(0.010)
KZ	-0.005***	-0.001***	-0.002***
	(0.001)	(0.000)	(0.000)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
F-test (p-value)	< 0.001		
Adj. R^2	0.440	0.153	0.140
Obs.	28,903	28,903	28,903

2.7 Possible Underlying Economic Mechanisms

This subsection explores possible underlying economic mechanisms through which foreign institutional investors motivate firm innovation, as predicted by the second hypothesis. It should be noted that while these economic mechanisms, which underlie the positive relationship between foreign institutional investors and firm innovation, are identified, they are not mutually exclusive and, if anything, may jointly contribute to the positive effect of foreign institutions on firm innovation.

2.7.1 Economic Mechanisms: Monitoring

Due to the agency problems created by the separation of ownership and control, a potential moral hazard problem arises in which firm managers either shirk or over-invest in routine tasks that are less challenging to enjoy their private benefits (Bertrand and Mullainathan, 2003; Hart, 1983). The myopia theory of Stein (1988) shows that managers may under-invest in innovation projects because these projects, by nature, are a high-risk and long-term investment that may not generate predictable returns in the short run.

Monitoring by institutional investors is thus an important governance mechanism to mitigate managerial myopia and slack. Compared with small investors, who are relatively less informed, institutional investors are better able to provide effective and active monitoring owning to their large ownership stake in the firms, as well as their ability to exploit the economy of scale in information acquisition and processing (e.g., Gillan and Starks, 2000, 2003; Grossman and Hart, 1988; Shleifer and Vishny, 1986). Not all types of institutions are actively engaged in monitoring, however. For instance, Bushee (1998) finds that institutional investors with short-term investments induce managerial myopia while institutions with long-term investments reduce this myopic behavior. Chen, Harford, and Li (2007) show that long-term institutions focus more on monitoring and influencing efforts than on trading, because the longer an institution has invested in a firm, the better is its stock of knowledge of the firm and its managers, and the better it is at processing new information about that firm. They also find that "independent" institutions are more inclined to gather information and get actively involved in the firms in which they invest, while "grey" institutions are more likely to hold shares without intervening in the firm's business. [7]

This study argues that if monitoring by foreign institutional investors contributes to increases in firm innovation, then those foreign institutions which have strong incentives to monitor, i.e., independent or long-term foreign institutions, should play a more significant role in promoting firm innovation.

To examine this hypothesis, foreign institutional ownership is first decomposed into two components: ownership by "independent" (or long-term) foreign institutions and ownership by "grey" (or short-term) foreign institutions. The baseline regressions are re-estimated but independent foreign institutions are distinguished from grey ones, and long-term foreign institutions from short-term ones. Specifically, the regression equation 2.1 is re-estimated where FIO is decomposed into $FIO_{Independent}$ and FIO_{Grey} or $FIO_{Long-term}$ and $FIO_{Short-term}$.

Table 2.6 contains the results on the effects of these types of foreign institutions on firm innovation. Panel A reports the results where the dependent variable is $Ln(1+Patent)$ and Panel B the results where the dependent variable is $Ln(1+Citation)$.

[7] Chen, Harford, and Li (2007) define mutual fund managers and investment advisors as "independent institutions" and bank trusts, insurance companies, pension funds, and endowments as "grey" institutions.

Column 1 in Panel A focuses on two key variables: the percentage of shares held by "independent" institutions ($FIO_{Independent}$), such as mutual funds and investment advisors, and the percentage of shares held by "grey" institutions (FIO_{Grey}), such as bank trusts, insurance companies, pension funds, or endowments. As shown, the coefficient estimate of $FIO_{Independent}$ is positive and highly significant at the 1% level, whereas the coefficient estimate of FIO_{Grey} is insignificant . These results show that among all foreign institutions, only institutions that are more actively engaged in monitoring play a role in promoting innovation.

In column 2 of Panel A, foreign institutional investors are classified into short-term and long-term institutions. The same regression equation 2.1 is re-estimated with a focus on two variables, $FIO_{Long-term}$ (the percentage of shares held by foreign institutions for more than one year) and $FIO_{Short-term}$ (the percentage of shares held by foreign institutions for less than one year). As expected, the coefficient on $FIO_{Long-term}$ is positive and statistically significant throughout at the 1% level, whereas the coefficient estimate of $FIO_{Short-term}$ is insignificant. These results suggest that the positive effect of foreign institutional ownership on firm innovation is driven mainly by long-term foreign institutional investors. Panel B, in which the same regression analysis is repeated for citations, shows similar findings.

Overall, this subsection shows that long-term and independent foreign institutions play a crucial role in motivating firm innovation. This evidence suggests that intensive monitoring by foreign institutional investors could be a possible underlying mechanism through which foreign institutional investors enhance firm innovation, and thus provides support for the monitoring channel that underlies the second hypothesis.

Table 2.6: Economic Mechanisms − Monitoring

This table presents the tests on how the monitoring channel explains the positive effect of foreign institutional ownership on firm innovation. Panel A reports the results where the dependent variable is the natural logarithm of one plus the number of patents ($Ln(1 + Patent)$). Panel B presents the results where the dependent variable is the natural logarithm of one plus the number of citations received by patents ($Ln(1 + Citation)$). Foreign institutional ownership is classified into independent and grey foreign institutional ownership (columns 1 and 3), or into long-term and short-term foreign institutional ownership (columns 2 and 4). All explanatory variables are lagged by one year and defined as in Appendix 2. All regressions include controls for industry, country, and year dummies. Robust standard errors are enclosed in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Panel A: $Ln(1 + Patent)$		**Panel B:** $Ln(1 + Citation)$	
	Independent/ Grey	Long-term/ Short-term	Independent/ Grey	Long-term/ Short-term
	1	2	3	4
$FIO_{Independent/Long-term}$	0.010***	0.010***	0.012***	0.013***
	(0.003)	(0.002)	(0.004)	(0.003)
$FIO_{Grey/Short-term}$	0.011	0.008	0.030	0.007
	(0.034)	(0.005)	(0.032)	(0.010)
DIO	-0.006**	-0.006**	-0.007*	-0.007*
	(0.003)	(0.003)	(0.003)	(0.003)
$Ln(AGE)$	0.046	0.046	0.051	0.051
	(0.088)	(0.089)	(0.089)	(0.089)
HHI	-0.063	-0.064	-0.125	-0.126
	(0.171)	(0.170)	(0.246)	(0.246)
$HHISQ$	0.118	0.120	0.166	0.171
	(0.183)	(0.180)	(0.215)	(0.213)
RD	1.577***	1.577***	1.866**	1.864**
	(0.558)	(0.557)	(0.739)	(0.737)
$CAEX$	1.369***	1.366***	1.859***	1.857***
	(0.311)	(0.309)	(0.365)	(0.366)
PPE	-0.234*	-0.233*	-0.204	-0.203
	(0.130)	(0.129)	(0.150)	(0.150)
LEV	-0.254*	-0.252	-0.333**	-0.330**
	(0.147)	(0.149)	(0.126)	(0.128)
ROA	-0.203	-0.202	-0.416**	-0.416**
	(0.187)	(0.187)	(0.177)	(0.178)
$Ln(SALE)$	0.161***	0.161***	0.187***	0.188***
	(0.018)	(0.019)	(0.025)	(0.025)
Q	0.038***	0.038***	0.059***	0.059***
	(0.010)	(0.010)	(0.013)	(0.013)
KZ	-0.001**	-0.001**	-0.002***	-0.002***
	(0.000)	(0.000)	(0.001)	(0.001)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Adj.R^2	0.153	0.153	0.145	0.145
Obs.	28,903	28,903	28,903	28,903

2.7.2 Economic Mechanisms: Insurance

Research on incentives for innovation in the economics and psychology literature has shown that while the standard pay-for-performance incentive scheme motivates high efforts in routine tasks, it may actually undermine performance in tasks that require creativity and exploration (Ederer and Manso, 2013; Glucksberg, 1962). The incentive schemes that motivate innovation must exhibit substantial tolerance for failures (Holmström, 1989; Manso, 2011), which implies that compensation schemes that are less sensitive to firm performance can be used to motivate innovation.

The recent work of Aghion, Van Reenen, and Zingales (2013) shows that managerial turnover in U.S. firms is less sensitive to firm performance in the presence of institutional investors, consistent with the argument that institutional investors provide partial insurance to managers with career or reputation concerns against failure risks arising from their innovation activities. The experimental study of Ederer and Manso (2013) shows that a manager's incentive to innovate is undermined by a threat of contractual termination.

Based on these studies, this study argues that if foreign institutional investors promote innovation by insulating managers from punishment for failures, which are likely due to the high uncertainty and risk associated with innovation projects, then the sensitivities of CEO turnover and compensation to firm performance should be weaker in the presence of foreign institutions.

To test this conjecture, this study uses CEO turnover data from the BoardEx database to match with the sample firms for the 2000–2010 period. The match results in a total of 167 CEO turnover events, producing 755 firm-year observations. Similarly, CEO compensation data are collected from BoardEx and matched with the sample firms, which produces a matched sample of 785 firm-year observations.

To test the effect of foreign institutional ownership on CEO turnover-performance sensitivity, this study follows Aghion, Van Reenen, and Zingales (2013) and estimates the following probit model:

$$\begin{aligned} CEOTurnover_{i,t} &= \alpha + \beta_1 \Delta ROA_{i,t-1} + \beta_2 (FIO_{i,t-1} \times \Delta ROA_{i,t-1}) \\ &\quad + \beta_3 (DIO_{i,t-1} \times \Delta ROA_{i,t-1}) + \beta_4 FIO_{i,t-1} + \beta_5 DIO_{i,t-1} \\ &\quad + \beta_6 Ln(MCap)_{i,t-1} + \varphi_t + \phi_k + \omega_j + \varepsilon_{i,t}, \end{aligned} \tag{2.3}$$

where i, k, j, and t refer to firm i, industry k, country j, and year t, respectively. $CEOTurnover$ is a dummy that equals one if the CEO leaves firm i during year t, and zero otherwise. ΔROA is the change in profitability in percentage points. The specification includes year (φ), industry (ϕ), and country (ω) fixed effects. For easier interpretation, marginal effects of all independent variables are reported.

To examine the effect of institutional ownership on CEO pay-performance sensitivity, this study follows Hartzell and Starks (2003) to estimate the following regression model:

$$\begin{aligned} \Delta CEOCash(Total)Compensation_{i,t} &= \alpha + \beta_1 \Delta Wealth_{i,t-1} \\ &\quad + \beta_2 (FIO_{i,t-1} \times \Delta Wealth_{i,t-1}) \\ &\quad + \beta_3 (DIO_{i,t-1} \times \Delta Wealth_{i,t-1}) \\ &\quad + \beta_4 FIO_{i,t-1} + \beta_5 DIO_{i,t-1} \\ &\quad + \beta_6 Ln(MCap)_{i,t-1} \\ &\quad + \varphi_t + \phi_k + \omega_j + \varepsilon_{i,t}, \end{aligned} \tag{2.4}$$

where i, k, j, and t refer to firm i, industry k, country j, and year t, respectively.

$\Delta CEOCash(Total)Compensation$ is the change in the level of cash and bonus compensation (total compensation includes cash, bonus, equity, option, and long-term incentive plans), $\Delta Wealth$ is the change in the value of the shares outstanding times stock price from period $t-1$ to t, and $Ln(MCap)$ is the natural logarithm of market capitalization. The specification includes year (φ), industry (ϕ), and country (ω) fixed effects .

Column 1 of Table 2.7 reports the results for the regression estimating equation (2.3). Consistent with previous literature, a higher profitability growth is associated with a lower probability that the CEO will be fired, as suggested by a negative and significant coefficient estimate of ΔROA. More importantly, the coefficient estimate of the interaction term ($FIO \times \Delta ROA$) is positive and significant at the 5% level, which suggests that the negative effect of performance on CEO turnover is mitigated by greater foreign institutional ownership. To put it differently, the sensitivity of CEO turnover to firm performance is lower in firms with higher foreign institutional ownership. This result is consistent with the "career concern" argument in Aghion, Van Reenen, and Zingales (2013) that institutional investors motivate innovation by providing managers with assurance against career risks, which stem from innovation failures when there is "bad news" about innovation attempts.

Columns 2–3 in Table 2.7 show the pooled OLS results estimating equation (2.4) to check how foreign institutional ownership alters the sensitivity of CEO pay to firm performance. Consistent with Hartzell and Starks (2003), changes in the shareholders' wealth are significantly positively related to changes in CEO compensation. The coefficient of interest on ($FIO \times \Delta Wealth$) is negative and significant at the 5% or 1% level across both specifications, which suggests that a greater foreign institutional ownership is associated with a weaker sensitivity of CEO pay to firm performance.

Overall, this subsection shows that the sensitivities of CEO pay and turnover to firm performance are weaker in the presence of greater foreign institutional ownership. This evidence supports the argument for the insurance channel that foreign institutional investors, by providing insurance against possible innovation failure risks to managers with career or reputation concerns, enable them to focus more on long-term, risky investment in innovation, and thus positively contribute to their investee firms' innovation.

Table 2.7: Economic Mechanisms – Insurance

This table presents the tests on how the career concern channel explains the effect of foreign institutional ownership on firm innovation. Column 1 presents the results of probit regressions of CEO turnover on foreign institutional ownership (FIO), where the dependent variable is a dummy variable equal to one if the CEO at the end of the year is different from the CEO at the end of the previous year and zero otherwise. The main independent variable is the interaction between the change in profitability and foreign institutional ownership ($FIO \times \Delta ROA$). The marginal effects are shown above the standard errors (in parentheses). Columns 2–3 show the results of regressions of the change in managers' compensation on foreign institutional ownership, where the dependent variables are measured by the change in cash and bonus compensation (column 2) and the change in total compensation (column 3). The main independent variables are the interactions between the change in shareholders' wealth and foreign institutional ownership ($FIO \times \Delta Wealth$). All regressions include controls for year, industry, and country dummies. Robust standard errors are in parentheses. All explanatory are lagged by one year. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Dummy (CEO Turnover)	ΔCEO Cash Compensation	ΔCEO Total Compensation
	1	2	3
$(FIO \times \Delta ROA)$	0.002**		
	(0.001)		
$(DIO \times \Delta ROA)$	0.000		
	(0.000)		
ΔROA	-0.011*		
	(0.006)		
$(FIO \times \Delta Wealth)$		-0.006***	-0.013**
		(0.002)	(0.006)
$(DIO \times \Delta Wealth)$		-0.002	-0.002
		(0.002)	(0.006)
$\Delta Wealth$		0.211***	0.287**
		(0.041)	(0.104)
FIO	-0.002	4.426	16.596*
	(0.002)	(4.398)	(9.398)
DIO	-0.001	-2.130	-7.182*
	(0.001)	(2.272)	(3.624)
$Ln(MCap)$	-0.009	-0.023**	-0.011
	(0.008)	(0.011)	(0.040)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Pseudo R^2/Adj. R^2	0.069	0.120	0.072
Obs.	755	785	785

2.7.3 Economic Mechanisms: Technology Spillovers

Knowledge spillovers are likely to be one of the channels through which innovation may occur. For example, investment in the creation of knowledge by one party facilitates innovation by others (Jaffe, Trajtenberg, and Fogarty, 2000). A number of well-documented factors contribute to the knowledge spillover process, such as research networks (Giuri and Mariani, 2013) or mobility of human capital (Agrawal, Cockburn, and McHale, 2006). Relatedly, Guadalupe, Kuzmina, and Thomas (2012) formulate a theoretical model and show empirical evidence that domestic firms are likely to innovate after being acquired by foreign acquirers. Their findings support the notion that foreign investors can promote innovation through an assimilation of foreign technologies and a widening of access to foreign markets, thus strengthening managers' incentives to search for new products and technologies.

Along these lines,this study argues that one possible channel through which foreign institutional investors promote innovation is that they facilitate the transfer of technology and knowledge and allow local firms a greater access to larger markets and newer technologies. If this conjecture is supported, the innovativeness of institutional investors' home countries should play a role in firm innovation. In particular, foreign institutional investors from countries with a higher level of innovation should play a larger role in firm innovation than those from countries with a lower level of innovation, because the former can give better advice and/or have better expertise on how to accelerate technology transfers and how to acquire a better access to larger markets.

To test this conjecture, the regression equation (2.1) is re-estimated where FIO is decomposed into $FIO_{HighInno}$ and $FIO_{LowInno}$, and the results are presented in Table 2.8. Columns 1-4 report the results for patent counts and columns 5-

8 for patent citations. The coefficient estimates of $FIO_{HighInno}$ are positive and significant at the 1% level in all specifications regardless of the use of country-level innovativeness measures. By contrast, the coefficient estimates of $FIO_{LowInno}$, though positive, are statistically insignificant in all specifications. These results suggest that the positive effect of foreign institutional ownership on firm innovation is driven primarily by foreign institutions domiciled in high-innovation countries, suggesting that only foreign institutional investors from high-innovation countries promote firm innovation.

Overall, this subsection presents evidence that the country-level innovativeness of foreign institutional investors' home countries matters for firm innovation in investee countries. The evidence shows that only foreign institutions that come from high-innovation countries spur firm innovation, which lends support to the argument underlying the second hypothesis that foreign institutions can enhance firm innovation through technology transfers.

Table 2.8: Economic Mechanisms – Technology Spillover

This table reports the regression results on how the technology spillover channel explains the effect of foreign institutional ownership (FIO) on firm innovation. A country-level measure of innovativeness is constructed based on four ratios: the total number of patents applied by all residents of a country in a year scaled by (1) GDP ($Patent/GDP$), (2) total population ($Patent/Pop$), (3) total number of listed firms ($Patent/Firms$), and (4) country market capitalization ($Patent/Mcap$) measured in that year. An institution's home country is a high- (low-) innovation country if its measure of innovativeness is above (below) the median of all domiciled countries of sample institutional investors. Foreign institutional ownership is classified into ownership from high-innovation countries ($FIO_{HighInno}$) and ownership from low-innovation countries ($FIO_{LowInno}$). All regressions include controls for year, industry, and country dummies. Robust standard errors are in parentheses. All explanatory variables are lagged by one year. Variable definitions are in Appendix 2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Panel A: $Ln(1+Patent)$				**Panel B:** $Ln(1+Citation)$			
	$Patent/GDP$	$Patent/Pop$	$Patent/Firms$	$Patent/Mcap$	$Patent/GDP$	$Patent/Pop$	$Patent/Firms$	$Patent/Mcap$
	1	2	3	4	5	6	7	8
$FIO_{HighInno}$	0.010***	0.010***	0.012***	0.017***	0.014***	0.014***	0.017***	0.019***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)
$FIO_{LowInno}$	0.011	0.025	0.007	0.004	0.013	0.027	0.005	0.007
	(0.009)	(0.021)	(0.012)	(0.004)	(0.012)	(0.024)	(0.013)	(0.005)
DIO	-0.006**	-0.006**	-0.006**	-0.006**	-0.007*	-0.007**	-0.007**	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$Ln(AGE)$	0.045	0.045	0.045	0.045	0.051	0.050	0.050	0.050
	(0.089)	(0.089)	(0.089)	(0.089)	(0.090)	(0.090)	(0.089)	(0.089)
HHI	-0.065	-0.072	-0.064	-0.064	-0.127	-0.134	-0.123	-0.128
	(0.171)	(0.173)	(0.173)	(0.169)	(0.250)	(0.255)	(0.252)	(0.247)
$HHISQ$	0.122	0.127	0.122	0.121	0.173	0.179	0.171	0.175
	(0.180)	(0.181)	(0.181)	(0.179)	(0.214)	(0.218)	(0.216)	(0.213)
RD	1.581***	1.576***	1.577***	1.582***	1.870**	1.865**	1.864**	1.873**
	(0.556)	(0.555)	(0.555)	(0.557)	(0.735)	(0.734)	(0.734)	(0.736)
$CAEX$	1.372***	1.364***	1.368***	1.373***	1.865***	1.856***	1.860***	1.866***
	(0.309)	(0.311)	(0.308)	(0.308)	(0.363)	(0.365)	(0.361)	(0.361)
PPE	-0.233*	-0.234*	-0.233*	-0.234*	-0.202	-0.204	-0.203	-0.203
	(0.129)	(0.129)	(0.129)	(0.129)	(0.149)	(0.149)	(0.149)	(0.149)
LEV	-0.258*	-0.255	-0.256	-0.259*	-0.339**	-0.335**	-0.336**	-0.340**
	(0.151)	(0.150)	(0.151)	(0.151)	(0.132)	(0.130)	(0.132)	(0.132)
ROA	-0.206	-0.207	-0.205	-0.206	-0.422**	-0.423**	-0.421**	-0.422**
	(0.188)	(0.185)	(0.187)	(0.188)	(0.180)	(0.177)	(0.179)	(0.180)
$Ln(SALE)$	0.163***	0.162***	0.162***	0.163***	0.192***	0.191***	0.191***	0.192***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.024)	(0.024)	(0.024)	(0.024)
Q	0.039***	0.039***	0.039***	0.039***	0.061***	0.060***	0.060***	0.061***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.013)	(0.012)	(0.013)	(0.013)
KZ	-0.001**	-0.001**	-0.001**	-0.001**	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R2	0.153	0.153	0.153	0.153	0.144	0.145	0.145	0.144
Obs.	28,903	28,903	28,903	28,903	28,903	28,903	28,903	28,903

2.8 Conclusions

This study examines the effect of foreign institutional investors on firm innovation around the world. Using firm-level data across 26 economies for the 2000–2010 period, this study documents a positive effect of foreign institutional ownership on firm innovation. To establish causality, two identification strategies are employed: (i) a DiD approach that relies on the exogenous variation in foreign institutional ownership that is generated by a quasi-natural experiment and (ii) an instrumental variable approach. The identification tests suggest that this positive effect is causal.

After establishing causality, this study investigates three possible underlying economic mechanisms through which foreign institutional investors promote innovation. The results show that foreign institutions enhance firm innovation by (i) providing active monitoring, (ii) providing firm managers who have career or reputation concerns with insurance against possible risks of innovation failures, and (iii) facilitating technology transfers from high-innovation countries.

Overall, this study provides the first rigorous empirical study that examines the roles of foreign institutional investors in motivating technological innovation. The findings documented in this study shed new light on the real effects of foreign institutional investors and has important policy implications for policymakers who aim to promote technological innovation.

Chapter 3

Institutional Investor Heterogeneity and Information Asymmetry

3.1 Introduction

Over the last several decades, institutional investors have become the most important shareholders of U.S. firms, generating great academic interest in their roles in the financial markets. To date, theoretical and empirical work has documented strong support for the information and monitoring roles of institutional investors (e.g., Baik, Kang, and Kim, 2010; Bennett, Sias, and Starks, 2003; Gompers and Metrick, 2001; Sias, Starks, and Titman, 2006; Yan and Zhang, 2009). Although institutional investors are often treated as a homogeneous group of large investors, there are several dimensions along which institutional investors are heterogeneous. Apart from investment objectives and styles, institutional investors also differ in investment horizons and ownership concentration, as well as in monitoring incentives. These differences are likely to produce differential effects on investee firms' information environments. While one group of institutional investors may have stronger incentives to monitor and pressure management, another group may place greater emphasis on gathering and processing information for the purpose of trading for short-term profits, which suggests that their involvement in a firm in the form of stock ownership can exacerbate its information environment. Despite this inherent heterogeneity, there has been limited empirical evidence to date on how differences in institutional characters are related to information asymmetry at the firm level. This study fills this gap in the literature by examining the relationship between the heterogeneity of institutional investors and information asymmetry.

To follow the literature on market microstructure, this study uses two widely used proxies for information asymmetry: the probability of informed trading (PIN) measure of Easley, Hvidkjaer, and O'Hara (2002) and the adjusted probability of informed trading ($AdjPIN$) of Duarte and Young (2009). This study provides evidence that institutional ownership heterogeneity is related to information asymmetry as captured by PIN and $AdjPIN$. Specifically, while information asymmetry is significantly positively associated with short-term institutional ownership, it is significantly negatively related to total institutional ownership, top-five largest institutional ownership, institutional ownership concentration, independent institutional ownership, and long-term institutional ownership. These results suggest that ownership concentration, investment horizon, and type of institutions have significant effects on a firm's information environment. Moreover, the number of institutional investors is negatively associated with information asymmetry measures, which is consistent with the prior literature that shows that increasing the number of informed investors results in prices that reflect more information. Overall, this study adds to the literature by providing comprehensive evidence on the effect of institutional investor heterogeneity on a firm's information environment.

The remainder of this chapter is organized as follows. Section 3.2 presents literature review and hypothesis development. Section 3.3 describes data, variables, and methodology. Section 3.4 presents empirical results. Section 3.5 concludes.

3.2 Literature Review and Hypothesis Development

One strand of literature has documented that institutional investors are better able to provide effective and active monitoring because of their large ownership stakes in the firms. Institutional investors can monitor through direct intervention by correcting managerial inefficiency or by engaging in implementing profitable projects (Gillan and Starks, 2000, 2003; Hartzell and Starks, 2003; Shleifer and Vishny, 1986). They can also monitor through threats of exit or sales of their shareholdings, which can then influence managerial decisions because selling shares would depress a firm's stock price when they typically hold large equity positions in the firm (Admati and

Pfleiderer, 2009; Edmans, 2009; Edmans and Manso, 2011; Parrino, Sias, and Starks, 2003).

Another related stream of work has suggested that institutional investors possess informational superiority because of their ability to exploit the economy of scale in information production and processing. Bushee, Matsumoto, and Miller (2004) show that firms with greater institutional ownership are less likely to have conference calls, which suggests that institutional investors can produce information and thus reduce the need for conference calls. Gompers and Metrick (2001) find that institutional ownership conveys information about stock returns. Bushee and Goodman (2007) find that changes in ownership by institutional investors with large positions in a firm are positively associated with that firm's future earnings. Chiang, Qian, and Sherman (2010) document that stock returns are higher when more institutional investors enter the auction or bid higher prices in Taiwan's IPO market.

Based on these strands of literature, this study argues that effective monitoring by institutional investors should help mitigate the severity of a firm's asymmetric information. For instance, institutional investors can directly intervene by pressing a firm to disclose information in a timely manner, thus making stock price more informative about the firm's fundamental value. Healy, Hutton, and Palepu (1999) provide support for this argument by documenting a positive association between institutional ownership and financial analysts' ratings of overall corporate disclosure practices. Similarly, Velury and Jenkins (2006) find a positive relation between institutional ownership and earnings quality, which suggests that institutional investors may improve the firm's information environment and thus attenuate information asymmetry. Based on this body of literature, the following hypothesis can be formulated:

Hypothesis 3.1: *Institutional ownership is negatively associated with information* *asymmetry.*

One dimension of institutional investor heterogeneity that may affect information asymmetry is ownership concentration. Compared with diffusely dispersed ownership, block ownership is presumably associated with greater informational advantages. Piotroski and Roulstone (2004) argue that different types of institutional investors possess different types of information advantages. They find that although institutional investors can influence a firm's information environment, the types of price-relevant information transmitted by their actions depend on each party's relative informational advantages.

On the one hand, institutional ownership concentration may produce "alignment effects" between the manager's and shareholders' interests through more effective monitoring, because concentrated institutional ownership strengthens shareholder control rights (Barclay and Holderness, 1992; Huddart, 1993). These alignment effects can attenuate information asymmetry regarding a firm's fundamental value. Hartzell and Starks (2003) show that institutional ownership concentration has a positive effect on the sensitivity of executive pay to firm performance while negatively affecting compensation levels, which suggests that concentration serves as a monitoring mechanism through which to mitigate the agency problem between the manager and shareholders. Burns, Kedia, and Lipson (2010) find that institutional ownership concentration is negatively associated with firms' financial restatements, which suggests that concentrated ownership induces greater monitoring and increases the information quality of their financial reports.

On the other hand, institutional investors with large blockholdings may exert "entrenchment effects" if they focus on exploiting information advantages for their own private benefits. Edmans (2014) shows that blockholders may induce the firm to buy products from another company that they own at inflated prices. Such entrenchment effects may exacerbate the agency problem. Heflin and Shaw (2000) provide evidence that blockholder ownership increases the informed trading component of the effective spreads, which consequently reduces the firm's stock liquidity. Bushee and Goodman (2007) find that the private information content of an institutional investor's trade is increasing in his stake. Similarly, Brockman and Yan (2009) document that blockholder ownership increases the probability of informed trading. Aslan et al. (2011) find that information asymmetry increases with the shareholdings of top-five largest institutional investors.

On balance, these two views suggest that institutional blockholder ownership may ameliorate or exacerbate information asymmetry depending on whether the benefits from monitoring outweigh those from exploiting private information. If the alignment effects dominate the entrenchment effects, there should be a negative relation between institutional ownership concentration and information asymmetry. By contrast, if the entrenchment effects dominate the alignment effects, there should be a positive relation between institutional ownership concentration and information asymmetry. Based on this body of literature, the following hypotheses can formulated:

Hypothesis 3.2a: *Institutional ownership concentration is positively associated with information asymmetry.*

Hypothesis 3.2b: *Institutional ownership concentration is negatively associated with information asymmetry.*

Aside from ownership concentration, institutional investors are also heterogeneous as to type and strength of monitoring incentives. Defining mutual fund managers and investment advisors as "independent" institutions, and bank trusts, insurance companies, pension funds, and endowments as "grey" institutions, Chen, Harford, and Li (2007) and Ferreira and Matos (2008) find that independent institutions have much stronger monitoring incentives while grey institutions are more likely to hold shares without reacting to management action that does not align with the best interests of shareholders. Thus, monitoring by independent rather than grey institutions has the potential to mitigate information asymmetry. Based on these studies and arguments, the following hypothesis can be formulated:

Hypothesis 3.3: *Independent institutional ownership is negatively associated with information asymmetry.*

Another important dimension of institutional investor heterogeneity is investment horizon. An emerging strand of literature has suggested that the investment horizon of institutional investors is significantly related to monitoring incentives. On the one hand, one stream of work suggests that short-term institutional investors are more likely to engage in privately informed trading and exert weak monitoring effort. For example, Bushee (1998) finds that firms with a large transient institutional investor base tend to be significantly myopic in their investment behaviors. Bushee (2001) finds that short-term institutional ownership is positively associated with the amount of firm value in expected short-term earnings. Ke and Petroni (2004) find that transient institutions possess information that allows them to predict upcoming earnings decreases so that they can avoid negative stock price responses. Gaspar, Massa, and Matos (2005) find that short-term institutions are also associated with weak monitoring incentives as well as weak bargaining positions in acquisitions. Yan and Zhang (2009) find that short-term institutional ownership significantly predicts stock returns but long-term institutional ownership does not. Burns, Kedia, and Lipson (2010) document that transient institutions degrade the quality of information, as manifested in higher levels of discretionary accruals.

By contrast, another stream of work has shown that long-term institutions tend to engage in active monitoring. Chen, Goldstein, and Jiang (2007) find that long-term institutions have stronger incentives to provide effective monitoring, which is manifested in better post-merger firm performance. Elyasiani and Jia (2010) find that the stability of institutional ownership is positively associated with firm performance, suggesting that institutions with a long-term focus actively engage in monitoring to enhance firm value. Elyasiani, Jia, and Mao (2010) find that the stability of institutional ownership reduces a firm's cost of debt. Attig et al. (2012) show that the sensitivity of a firm's investment outlays to internal cash flows decreases in the presence of institutional investors with long-term investment horizons.

Overall, these strands of literature suggest that a firm's information environment is affected by both short-term and long-term institutions. Based on the above discussions, the following hypothesis can be formulated:

Hypothesis 3.4: *Short-term institutional ownership is positively associated with information asymmetry while long-term institutional ownership is negatively associated with information asymmetry.*

Edmans and Manso (2011) propose a theoretical model that suggests that the number of blockholders is an important feature in driving both price efficiency and the strength of corporate governance because price efficiency requires not only that investors be informed but also that they impound their information into prices. This implies that the number of blockholders should be negatively associated with the degree of information asymmetry. There has been empirical evidence in support of Edmans and Manso's (2011) model predictions. Gallagher, Gardner, and Swan (2013) find supporting empirical evidence for a sample of Australian fund managers' daily trade data. Gorton, Huang, and Kang (2013) find that stock price informativeness is increasing in the number of blockholders. Based on this strand of literature, the following hypothesis can be formulated:

Hypothesis 3.5: *The number of institutional investors and of institutional blockholders is negatively associated with information asymmetry.*

3.3 Data, Variables, and Methodology

3.3.1 Data

This study begins with all common stocks listed on the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX) for the 1993–2007 period. Stock return, share price,shares outstanding, and firm age are obtained from the Center for Research in Security Prices (CRSP). Accounting data are obtained from Compustat. Insider transactions and institutional holdings are obtained from the Thomson Reuters ownership database. The Securities and Exchanges Commission (SEC) requires that all institutional investors with greater than \$100 million of securities under discretionary management report all of their equity positions more than 10,000 shares or \$200,000 to the SEC at the end of each quarter. Analyst coverage data are obtained from the Institutional Brokers Estimate System (I/B/E/S). Trades and quotes are from the Trade and Automated Quote (TAQ) database.

Because the daily number of trades has increased substantially in recent years, it is technically infeasible to estimate PIN and $AdjPIN$ for many heavily traded stocks due to the numerical overflow problem (see, for example, Duarte and Young, 2009; Easley, Hvidkjaer, and O'Hara, 2010). This study uses a sample period starting from 1993 through 2007 because TAQ data are available from 1993 only. Financial companies (SIC 6000–6999), utilities (SIC 4900–4999), American Depository Receipts (ADRs), Real Estate Investment Trusts (REITs), stocks of companies incorporated outside of the U.S., and closed-end funds are all excluded. Also excluded is any stock that does not have at least 60 days of quotes or trades in a year because it is impossible to estimate the PIN and $AdjPIN$ models reliably for such a stock. To avoid including trades that occur during the opening and closing auctions, all trades and quotes that occur before and at the open and those at and after the close are excluded. To eliminate possible data errors, all quotes with zero bid and/or ask prices as well as trades at zero prices are also excluded. Finally, firms must have non-missing stock returns or accounting data to be retained in the sample. All variables are winsorized at the top and bottom 1% tails to eliminate the effects of outliers. The final sample consists of 3,782 firms with 19,362 firm-year observations.

3.3.2 Variables

Information Asymmetry

The Probability of Informed Trading (PIN)

Easley et al. (1996) develop a structural market microstructure model in which orders come from either noise (uninformed) traders or informed traders. Informed traders trade for speculative purposes using their superior and private information, while noise traders trade for exogenous reasons such as liquidity needs. PIN is an estimate of the probability that an observed trade in a stock originates from privately informed traders during a specific period. If the number of buy (sell) orders on a trading day follows the Poisson distribution, the likelihood function of the PIN model is specified as follows:

$$\begin{aligned} L(\vartheta|B,S) \quad = \quad & (1-a)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} + ade^{-(u+\varepsilon_b)}\frac{(u+\varepsilon_b)^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \\ & +a(1-d)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-(u+\varepsilon_s)}\frac{(u+\varepsilon_s)^S}{S!}, \end{aligned} \tag{3.1}$$

where $B(S)$ is the number of buys (sells) for a given day. $\vartheta = (a, d, u, \varepsilon_b, \varepsilon_s)$ is a vector of parameters, in which a is the probability that an information event occurs during a trading day, d is the probability that good news arrives, $(1 - d)$ is the probability that bad news arrives if the information event occurs, u is the arrival rate of buy or sell orders submitted by informed traders, and $\varepsilon_b(\varepsilon_s)$ is the arrival rate of buy (sell) orders submitted by uninformed traders.

With the parameters $\vartheta = (a, d, u, \varepsilon_b, \varepsilon_s)$ estimated by maximizing the log-likelihood function based on (3.1), Easley, Hvidkjaer, and O'Hara (2002) compute PIN as a fraction of orders that originates from informed traders relative to the total order flow, as follows:

$$PIN = \frac{au}{au + \varepsilon_b + \varepsilon_s}. \tag{3.2}$$

For each firm-year over the 1993–2007 period, PIN is estimated based on intraday data on trades and quotes of stocks from the TAQ database. The PIN focuses on trades and quotes from 9:30 am to 4:00 pm on a trading day. The Lee and Ready (1991) algorithm is used to classify buy-initiated trades (buys) and sell-initiated trades (sells). For each stock on each day, the total numbers of buys and sells are obtained by aggregating all buys and sells on that day. The log-likelihood function of equation (3.1) is shown in Appendix 3.

The Adjusted Probability of Informed Trading (AdjPIN)

The $AdjPIN$ proxy is based on Duarte and Young's (2009) extension of the PIN model, and defined as the ratio of the expected informed orders to the expected total order flow, as follows:

$$AdjPIN = \frac{a(du_b + (1-d)u_s)}{a(du_b + (1-d)u_s) + (\Delta_b + \Delta_s)(a\theta' + (1-a)\theta) + \varepsilon_b + \varepsilon_s}, \qquad (3.3)$$

where the parameters in (3.3) are derived from Duarte and Young's (2009) $AdjPIN$ model, $\theta(\theta')$ is the probability of a symmetric order-flow shock conditional on the absence (arrival) of private information, $\Delta_b(\Delta_s)$ is the arrival rate of buys (sells) caused by symmetric order-flow shock, $\varepsilon_s(\varepsilon_s)$ is the arrival rate of buy (sell) orders submitted by uninformed traders, and $u_b(u_s)$ is the arrival rate of buy (sell) orders submitted by informed traders if the information event occurs. The definitions of $\varepsilon_b, \varepsilon_s, a$, and d are the same as in equation (3.1). The likelihood function of the $AdjPIN$ model is shown in Appendix 4.

As a proxy for information asymmetry, $AdjPIN$ differs from PIN in several ways. A minor difference is that $AdjPIN$ allows for the arrival rate of informed buyers, u_b, to be different from that of informed sellers, u_s. This extension allows the $AdjPIN$ model to account for the fact that buy order flow has a substantially larger variance relative to sell order flow for almost all firms in the data. The major difference is that the $AdjPIN$ model allows for a new type of arrival rates of buys (sells) in the event of symmetric order-flow shock, that is, $\Delta_b(\Delta_s)$. Following Duarte and Young (2009), $AdjPIN$ is estimated for each firm-year over the sample period by setting $\theta = \theta'$. To avoid numerical overflow problems, this study uses $e^{-\lambda + X ln(\lambda) - \sum_{i=1}^{X} i}$ for any Poisson density function of the form $e^{-\lambda}\frac{\lambda^X}{X!}$ specified in (3.1). The common term in the joint probability density function is also factored out.

Heterogeneity of Institutional Investors

Drawn from the extant literature (e.g., Gompers and Metrick, 2001; Hartzell and Starks, 2003), the following variables are constructed:

- Institutional ownership (TIO): This variable is defined as the sum of shares held by all institutional investors divided by the firm's total shares outstanding at the end of the fiscal year. Observations with missing institutional ownership are set to zero.
- Institutional block ownership ($BLOCK$): This variable is defined as the sum of shares held by all institutional investors with over 5% of the firm's total equity ownership divided by the firm's total shares outstanding.
- Top-five largest institutional ownership ($TOP5$): This variable is defined as the sum of shares held by top-five largest institutional investors divided by the firm's total shares outstanding. The advantage of this measure is that it is not subject to the arbitrary cutoff point of 5% and thus it is a finer measure of ownership concentration.
- Ownership concentration ($TIOHHI$): This variable is measured based on the Herfindahl-Hirschman Index.
- Long-term and short-term institutional ownership: This study classifies institutional ownership into long-term and short-term in several ways based on the classification methods used in Bushee (1998, 2001), Gaspar, Massa, and Matos (2005), Yan and Zhang (2009), and Elyasiani and Jia (2010). The details of the variable constructions are as follows:

First, Bushee (1998, 2001) classifies institutional investors into three categories: transient, quasi-index, and dedicated institutions. Transient institutions have a high portfolio turnover and highly diversified equity portfolio, which is consistent with the notion that their interest in a firm is confined to the search for short-term trading profits only. Quasi-indexers have a low turnover, a long horizon, and a buy-and-hold investment strategy. Dedicated institutions are characterized by a large average investment in a firm and an extremely low turnover, which is consistent with the argument that these institutions invest in relationship building and have a strong commitment to supplying patient, long-term capital. Bushee (2001) also states that quasi-indexers and dedicated institutions provide firms with long-term stable ownership because they are geared towards long-term income and capital appreciation. In the first classification, this study follows Bushee (1998, 2001) and measures long-term institutional ownership (DED) as the sum of shares held by quasi-indexers and dedicated institutions divided by the firm's total shares outstanding. Similarly, short-term institutional ownership (TRA) is measured as the sum of shares held by transient institutions divided by the firm's total shares outstanding.

In the second classification, this study follows Gaspar, Massa, and Matos (2005) and Yan and Zhang (2009) to classify institutional ownership into short-term and long-term based on the average churn rate, which is calculated in the following steps:

1. Quarterly aggregate purchases and sells for each institution are computed:

$$CR_{k,t}^{\text{buy}} = \sum_{\substack{i=1 \\ S_{k,i,t} > S_{k,i,t-1}}}^{n} |S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}|, \quad (3.4)$$

$$CR_{k,t}^{\text{sell}} = \sum_{\substack{i=1 \\ S_{k,i,t} \leq S_{k,i,t-1}}}^{n} |S_{k,i,t}P_{i,t} - S_{k,i,t-1}P_{i,t-1} - S_{k,i,t-1}\Delta P_{i,t}|, \quad (3.5)$$

   where $P_{i,t}$ is the price of stock i at the end of quarter t, and $S_{k,i,t}$ is the number of shares of stock i held by investor k at the end of quarter t. Stock splits and dividends are adjusted using the CRSP adjustment factors.

2. The churn rate of institution k for quarter t is calculated and averaged over

the past four quarters, as follows:

$$
\begin{aligned}
CR_{k,t} &= \frac{\min\left(CR_{k,t}^{\text{buy}}, CR_{k,t}^{\text{sell}}\right)}{\sum_{i=1}^{n} \frac{S_{k,i,t}P_{i,t}+S_{k,i,t-1}P_{i,t-1}}{2}} && (3.6)\\
AVG_C R_{k,t} &= \frac{1}{4}\sum_{j=0}^{3} CR_{k,t-j} && (3.7)
\end{aligned}
$$

3. All institutions are then sorted into three groups based on the average churn rate. Short-term institutional investors are defined as those institutions that belong to the group of highest average churn rates and long-term institutional investors to the group of lowest average churn rates.

Short-term institutional ownership (SIO) is defined as the ratio of the number of shares held by short-term institutions to the firm's total number of shares outstanding. Long-term institutional ownership (LIO) is defined as the ratio of the number of shares held by long-term institutions to the firm's total number of shares outstanding.

In the third classification, this study follows Elyasiani and Jia (2010) and Elyasiani, Jia, and Mao (2010) and calculates the volatility of institutional ownership ($VTIO$) as the average standard deviation of shareholdings across all institutional investors over a five-year period (20 quarters), as follows:

$$
VTIO_j = \sum_{j=1}^{J_i} Std(TIO_{i,t}^{j})/J_i \tag{3.8}
$$

where $TIO_{i,t}^{j}$ is the proportion of institutional ownership in firm i held by investor j in quarter t, with $t = 1, 2, \ldots 20$, and J_i is the number of institutional investors in firm i.

The long-run average of shareholdings held by all institutional investors over 20 quarters ($ATIO$) for each firm in the sample is computed as follows:

$$ATIO_i = \left(\sum_{i=1}^{20} \sum_{j=1}^{J_i} TIO_{i,t}^{j} \right) \Big/ 20. \tag{3.9}$$

Because short-term institutional investors tend to buy and/or sell shares for short-term profits while the shareholdings of long-term institutional investors are relatively stable in the long run, $VTIO$ can be considered a proxy for short-term institutional ownership and $ATIO$ a proxy for long-term institutional ownership.

- Grey and independent institutional ownership ($GREY/INDEP$): Following Chen, Goldstein, and Jiang (2007), independent institutional ownership is defined as the sum of shares held by mutual fund managers and investment advisors over the firm's total shares outstanding. Grey institutional ownership is defined as the sum of shares held by bank trusts, insurance companies, pension funds, endowments, and other institutions over the firm's total shares outstanding.
- The number of institutional investors and the number of institutional blockholders ($NOI/NBLOCK$): The numbers of institutional investors and blockholders are measured at the end of the fiscal year.

Control Variables

To isolate the effect of institutional investors on a firm's information environment, this study uses a set of control variables that have been widely used in the empirical literature (e.g., Brockman and Yan, 2009; Chen, Goldstein, and Jiang, 2007; Ferreira and Laux, 2007; Piotroski and Roulstone, 2004).

- Firm size ($SIZE$): Firm size is defined as the natural logarithm of market capitalization ($MCAP$), where $MCAP$ is calculated as share price times total shares outstanding at the end of the fiscal year (in USD billions). Both share price and shares outstanding are corrected for stock splits and dividends using the CRSP cumulative adjustment factors.
- Firm age ($Ln(AGE)$): This variable is defined as the natural logarithm of the number of years (AGE) since first return appears in CRSP.
- Market-to-Book ratio (MTB): This variable is defined as the market value over the book value of equity at the end of the fiscal year.
- Turnover ($TURN$): Turnover is the average monthly share trading volume over total shares outstanding over the past twelve months.
- Leverage (LEV): This variable is calculated as the ratio between the current and long-term debt and the book value of total assets at the end of the fiscal year.
- Return on assets (ROA): Return on assets is calculated as the ratio of operating income before depreciation, interest, and extraordinary items to the book value of total assets at the end of the fiscal year.
- Volatility of return on assets ($VROA$): This variable is measured as the standard deviation of ROAs scaled by the book value of total assets over the preceding three years.
- Dividend dummy ($DIVD$): This dummy equals one if a firm pays cash dividends during the fiscal year and zero otherwise.
- Diversification dummy ($DIVER$): This dummy equals one if a firm is a multi-segment corporation and zero otherwise.
- S&P 500 membership ($SP500$): This dummy equals one if the stock is a member of the S&P 500 index and zero otherwise.
- Analyst coverage ($ALYST$): Analysts disseminate private information through their earnings forecasts, revisions, and stock recommendations. Piotroski and Roulstone (2004) find that analysts increase the relative amount of market-

and industry-level information that is embedded in stock prices, which suggests that they are likely to reduce private information in stock prices. Analyst coverage is measured as the natural logarithm of the number of analysts following a firm in each fiscal year and set to zero if there is no information on the analyst coverage.

- Insider trading ($CLOSE$): Insiders transmit private information to market participants through their trading activity (e.g., Chen, Goldstein, and Jiang, 2007; Piotroski and Roulstone, 2004; Sias and Whidbee, 2010). Following Sias and Whidbee (2010), insider trading is defined as the difference between the number of shares purchased and the number of shares sold by insiders, scaled by the total number of shares outstanding at the end of the fiscal year.

3.3.3 Methodology

Although this study focuses specifically on the PIN and $AdjPIN$ measures as proxies for information asymmetry, it should be noted that both of these measures are not without weaknesses. For example, a theoretical objection against PIN is that this measure is based on assumptions which are not really realistic. For instance, information events may not be independent across days, or informed traders may not trade on their private information on the same day that they acquired it. Good news or bad news might arrive over a sequence of days, after which there is a complete absence of news over another sequence of days. Another limitation of PIN is that it cannot match the pervasive positive correlations between buyer and seller initiated order flows or the variances of buy and sell order flows as observed in the actual data, because it specifies only two possible motives for trading: information and exogenous liquidity needs. Despite these weaknesses, this study focuses on PIN and its variant $AdjPIN$ as widely used proxies for information asymmetry.

First, to examine the relationship between institutional ownership and information asymmetry, this study follows Ferreira and Laux (2007) and Brockman and Yan (2009) and estimate the following baseline regression:

$$INFOR_{i,t} = \beta_0 + \beta_1 TIO_{i,t-1} + \gamma' CONTROL_{i,t-1} + e_{i,t}, \tag{3.10}$$

where the dependent variable is proxied by either PIN or $AdjPIN$, both measured in year t. The key independent variable is TIO, measured in year $t-1$. $CONTROL$ is a vector of firm characteristics as discussed in Subsection 3.3.2, all measured in year $t-1$.

A negative and significant coefficient on β_1 will provide support for Hypothesis 3.1 that institutional ownership is negatively related to information asymmetry.

Second, to examine how type and concentration of institutional ownership are related to information asymmetry, the following model is estimated:

$$\begin{aligned} INFOR_{i,t} &= \alpha_0 + \alpha_1 CONCENTRATION/TYPE_{i,t-1} \\ &\quad + \gamma' CONTROL_{i,t-1} + e_{i,t}, \end{aligned} \tag{3.11}$$

where $CONCENTRATION$ is measured by top-five largest institutional ownership ($TOP5$), institutional block ownership ($BLOCK$), or institutional concentration ($TIOHHI$), all measured in year $t-1$. $TYPE$ refers to either independent ($INDEP$) or grey ($GREY$) institutional ownership, both measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as in equation (3.10).

The key variable is α_1, the coefficient on $CONCENTRATION$. If α_1 is positive and statistically significant, then Hypothesis 3.2a is supported. By contrast, a negative and significant coefficient estimate of α_1 will provide support for Hypothesis 3.2b.

Third, to examine how the investment horizon of institutional investors affects information asymmetry, the following regression is estimated:

$$\begin{aligned} INFOR_{i,t} &= \lambda_0 + \lambda_1 TIO^{\text{short}}_{i,t-1} + \lambda_2 TIO^{\text{long}}_{i,t-1} \\ &\quad + \gamma' CONTROL_{i,t-1} + e_{i,t}, \end{aligned} \tag{3.12}$$

where TIO^{short} and TIO^{long} are short-term and long-term institutional ownership, respectively, both measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as in equation (3.10).

The key variables are λ_1 and λ_2, the coefficients on TIO^{short} and TIO^{long}, respectively. A positive and significant λ_1 and a negative and signficant λ_2 will provide support for Hypothesis H3.2, which postulates that information asymmetry is positively associated with short-term institutional ownership but negatively related to long-term institutional ownership.

Finally, to examine how the number of institutional investors and the number of institutional blockholders affect information asymmetry, the following model is estimated:

$$\begin{aligned} INFOR_{i,t} &= \upsilon_0 + \upsilon_1 NBLOCK/NOI_{i,t-1} \\ &\quad + \gamma' CONTROL_{i,t-1} + e_{i,t}, \end{aligned} \tag{3.13}$$

where $NBLOCK$ and NOI are the number of institutional block holders and the number of institutional investors, respectively, both measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as in equation (3.10).

A negative and significant coefficient on v_1 will provide support for Hypothesis 3.3, which posits that the number of institutional investors or of institutional blockholders attenuates information asymmetry.

3.4 Empirical Results

3.4.1 Descriptive Statistics

Table 3.1 reports the sample descriptive statistics. Panel A reports the summary statistics for the information asymmetry variables. Panel B shows the summary statistics for the institutional ownership variables. Panel C displays the summary statistics for the control variables.

On average, a stock has a PIN estimate of 0.200 and an $AdjPIN$ estimate of 0.165 over the sample period. Both PIN and $AdjPIN$ estimates are comparable with those of Easley, Hvidkjaer, and O'Hara (2002) and Duarte and Young (2009). The mean institutional ownership is 59% over the sample period. The average top-five largest institutional ownership is 23.8%, and the average institutional blockhoder ownership is 15.7%. On average, short-term institutional investors hold 19% of total shares outstanding, while long-term institutions hold 40.0%. Independent institutions own 41% of total equity ownership and grey institutions 15%. The average number of institutional blockholders is 1.8 and the average number of institutional investors is 114.

The average firm has a market capitalization of \$2.6 billion, about 12 years of CRSP return data, an ROA of 9%, and a leverage ratio of 26%. Its turnover rate and market-to-book ratio are 9.0% and 1.98, respectively.

Table 3.1: Summary Statistics

This table reports the summary statistics for the 1993–2007 sample period based on data from the TAQ, CRSP, Compustat, Thomson Reuters, and I/B/E/S databases. Variable construction is described in detail in Subsection 3.3.2.

	Firms	**Firm-Years**	**Mean**	**Std**	**Q1**	**Median**	**Q3**
			Panel A: Information Asymmetry				
PIN	3782	19,362	0.201	0.102	0.132	0.175	0.239
$AdjPIN$	3782	19,362	0.165	0.077	0.113	0.148	0.199
			Panel B: Institutional Ownership				
TIO	3,782	19,362	0.592	0.284	0.244	0.522	0.721
$TOP5$	3,782	19,362	0.238	0.133	0.147	0.234	0.318
$TOP10$	3,782	19,362	0.317	0.172	0.193	0.323	0.433
$BLOCK$	3,782	19,362	0.157	0.146	0.051	0.130	0.244
HHI	3,782	19,362	0.157	0.188	0.046	0.078	0.186
SIO	3,782	19,362	0.191	0.122	0.042	0.118	0.211
LIO	3,782	19,362	0.400	0.217	0.162	0.356	0.518
TRA	3,782	19,362	0.160	0.108	0.025	0.084	0.166
DED	3,782	19,362	0.431	0.226	0.186	0.401	0.560
$VTIO$	3,782	19,362	0.266	0.160	0.156	0.248	0.351
$ATIO$	3,782	19,362	0.380	0.210	0.139	0.330	0.509
$INDEP$	3,782	19,362	0.415	0.299	0.085	0.315	0.593
$GREY$	3,782	19,362	0.177	0.155	0.006	0.040	0.151
$NBLOCK$	3,782	19,362	1.798	1.556	1.000	2.000	3.000
NOI	3,782	19,362	113.823	145.636	21.000	71.000	146.000
			Panel C: Firm Characteristics				
$MCAP$	3,782	19,362	2.501	7.379	0.088	0.407	1.489
MTB	3,782	19,362	1.981	1.523	1.144	1.497	2.156
$TURN$	3,782	19,362	0.094	0.129	0.026	0.056	0.110
AGE	3,782	19,362	12.383	1.130	6.209	12.420	12.526
LEV	3,782	19,362	0.263	0.217	0.086	0.239	0.383
$CASH$	3,782	19,362	0.130	0.183	0.017	0.054	0.159
RD	3,782	19,362	0.033	0.079	0.000	0.000	0.029
ROA	3,782	19,362	0.094	0.185	0.069	0.123	0.176
$VROA$	3,782	19,362	0.096	0.170	0.073	0.123	0.175
$DIVER$	3,782	19,362	0.909	0.287	1.000	1.000	1.000
$DIVD$	3,782	19,362	0.475	0.499	0.000	0.000	1.000
$SP500$	3,782	19,362	0.068	0.252	0.000	0.000	0.000
$ALYST$	3,782	19,362	4.342	2.284	1.000	3.751	20.303
$CLOSE$	3,782	19,362	0.014	0.049	0.000	0.000	0.005

3.4.2 Institutional Ownership and Information Asymmetry

This subsection presents the regression results of examining the relationship between institutional ownership and information asymmetry. Table 3.2 reports the results of estimating equation (3.10), where all regressions include year and industry dummies, as well as robust standard errors in parentheses. Panel A reports the results when PIN is the dependent variable. Panel B reports the results when $AdjPIN$ is the dependent variable.

Column 1 in both panels shows that the coefficient estimate of TIO is negative and highly significant at the 1% level. When firm characteristics are controlled for (column 2), this coefficient remains negative and statistically significant, although the size of the coefficient becomes smaller. The coefficient estimate of -0.044, in column 2 of Panel A, suggests that a 1% increase in total institutional ownership is associated with a 4.4% decrease in the probability that an observed trade originates from privately informed investors. This result suggests an inverse relationship between institutional ownership and information asymmetry, which lends support to Hypothesis 3.1.

With regard to control variables, column 2 of Panel A shows that firm size, market to book ratio, turnover, and R&D expenditure are negatively associated with information asymmetry—results which are consistent with prior literature (e.g., Aslan et al., 2011). Firms with greater cash holdings tend to have greater information asymmetry, as suggested by a positive and significant coefficient estimate of $CASH$. Myers and Majluf (1984) find that to avoid costly external financing, firms with greater information asymmetry should benefit from having greater cash holdings.

In columns 3-5, the membership of the S&P 500 index, analyst coverage ($ALYST$), and insider trading ($CLOSE$) are added as control variables. The results show that the coefficient on TIO remains negative and significant. As expected, the coefficient on $ALYST$ is negative and significant in all regressions, consistent with findings in prior work that analyst coverage increases the relative amount of market- and industry-wide information about the firm and thus reduces the relative amount of firm-specific information in stock prices. The coefficient estimate of $CLOSE$ is positive, suggesting that insider trading is positively associated with private information in stock prices. Overall, the results suggest that the negative effect of institutional ownership on information asymmetry measures is not subsumed by analyst coverage and insider trading.

In Panel B, where $AdjPIN$ is used as the dependent variable, the results show similar evidence. Although its size now becomes smaller, the coefficient estimate of TIO remains negative and highly significant at the 1% level, which suggests that institutional ownership is negatively associated with information asymmetry.

Table 3.2: Institutional Ownership and Information Asymmetry

This table reports the following pooled OLS regression:

$$INFOR_{i,t} = \beta_0 + \beta_1 TIO_{i,t-1} + \gamma_j CONTROL_{i,t-1} + e_{i,t}.$$

The dependent variable is either one of the two proxies: PIN (Panel A) or $AdjPIN$ (Panel B), both measured in year t. The key independent variable is institutional ownership (TIO), measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as discussed in Subsection 3.3.2, all measured in year $t-1$. All regressions include year and industry dummies. Robust standard errors are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Probability of Informed Trading (PIN)					
	1	2	3	4	5
TIO	-0.174***	-0.044***	-0.042***	-0.042***	-0.042***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
$SIZE$		-0.029***	-0.030***	-0.029***	-0.029***
		(0.002)	(0.001)	(0.002)	(0.002)
MTB		-0.002***	-0.002***	-0.002***	-0.002***
		(0.001)	(0.001)	(0.001)	(0.001)
$TURN$		-0.094***	-0.095***	-0.096***	-0.096***
		(0.011)	(0.011)	(0.011)	(0.011)
$Ln(AGE)$		0.002	0.001	0.002	0.002
		(0.001)	(0.001)	(0.001)	(0.001)
LEV		0.001	0.002	0.001	0.001
		(0.005)	(0.005)	(0.005)	(0.005)
$CASH$		0.013**	0.014**	0.012**	0.012**
		(0.006)	(0.006)	(0.006)	(0.006)
RD		-0.057***	-0.058***	-0.054***	-0.054***
		(0.015)	(0.015)	(0.014)	(0.014)
ROA		0.014**	0.014**	0.014**	0.013**
		(0.007)	(0.006)	(0.007)	(0.007)
$VROA$		0.011	0.012	0.012	0.012
		(0.012)	(0.012)	(0.012)	(0.012)
$DIVER$		0.001	0.002	0.002	0.002
		(0.003)	(0.003)	(0.003)	(0.003)
$DIVD$		0.000	0.000	0.000	0.000
		(0.002)	(0.002)	(0.002)	(0.002)
$SP500$			0.014***	0.016***	0.016***
			(0.004)	(0.004)	(0.004)
$ALYST$				-0.004***	-0.004***
				(0.001)	(0.001)
$CLOSE$					0.026**
					(0.013)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.265	0.456	0.457	0.458	0.458
Obs.	19,362	19,362	19,362	19,362	19,362

Panel B: Adjusted Probability of Informed Trading ($AdjPIN$)					
	1	2	3	4	5
TIO	-0.119***	-0.026***	-0.025***	-0.025***	-0.025***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)
$SIZE$		-0.022***	-0.022***	-0.021***	-0.021***
		(0.001)	(0.001)	(0.001)	(0.001)
MTB		-0.002***	-0.002***	-0.002***	-0.002***
		(0.001)	(0.001)	(0.001)	(0.001)
$TURN$		-0.057***	-0.057***	-0.057***	-0.058***
		(0.007)	(0.007)	(0.006)	(0.007)
$Ln(AGE)$		-0.001	-0.001	0.000	0.000
		(0.001)	(0.001)	(0.001)	(0.001)
LEV		0.000	-0.001	0.000	0.000
		(0.004)	(0.004)	(0.004)	(0.004)
$CASH$		0.005	0.005	0.004	0.004
		(0.003)	(0.003)	(0.004)	(0.004)
RD		-0.027***	-0.027***	-0.025***	-0.025***
		(0.007)	(0.007)	(0.007)	(0.007)
ROA		0.010*	0.010*	0.010	0.009
		(0.006)	(0.006)	(0.006)	(0.006)
$VROA$		0.019**	0.020**	0.019**	0.020**
		(0.008)	(0.008)	(0.009)	(0.009)
$DIVER$		0.001	0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)	(0.002)
$DIVD$		0.000	0.000	0.001	0.001
		(0.002)	(0.002)	(0.002)	(0.002)
$SP500$			0.002	0.004	0.004
			(0.002)	(0.002)	(0.002)
$ALYST$				-0.003***	-0.003***
				(0.001)	(0.001)
$CLOSE$					0.014*
					(0.007)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.240	0.420	0.420	0.422	0.422
Obs.	19,362	19,362	19,362	19,362	19,362

As a robustness check on the baseline results, Table 3.3 presents the results of different estimation methods. First, the two-pass Fama and MacBeth (1973) estimation method is used to account for possible cross-sectional correlations between firms in a given year. Column 1 shows that the coefficient estimates of TIO remain negative and highly significant. Second, the firm fixed effects regression is used to partially address the omitted variable problem. Including firm fixed effects absorbs time-invariant unobservable firm characteristics that affect both institutional ownership and information asymmetry proxies. Again, Column 2 shows that the coefficient estimates of TIO remain negative and highly significant.

Table 3.3: Institutional Ownership and Information Asymmetry – Robustness Checks

This table reports the coefficient estimates from the alternative regressions of PIN ($AdjPIN$) on TIO and other control variables. Columns 1–2 show the firm fixed effects and the Fama and MacBeth's (1973) regressions, respectively. Columns 3–4 display the results of a system of simultaneous equations, in which the dependent variables are PIN ($AdjPIN$) and TIO. Robust standard errors are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Probability of Informed Trading (PIN)

			Simultaneous Equations	
	FM	FE	PIN	TIO
	1	2	3	4
TIO	-0.060***	-0.026***	-0.067***	
	(0.007)	(0.008)	(0.003)	
$SIZE$	-0.027***	-0.028***	-0.027***	0.074***
	(0.002)	(0.002)	(0.000)	(0.001)
MTB	-0.002***	0.001	-0.003***	-0.035***
	(0.001)	(0.001)	(0.000)	(0.001)
$TURN$	-0.106***	-0.067***	-0.106***	0.202***
	(0.011)	(0.011)	(0.005)	(0.014)
$Ln(AGE)$	0.002***	-0.004	0.003***	-0.004*
	(0.001)	(0.003)	(0.001)	(0.002)
LEV	-0.005**	0.002	0.003	0.004
	(0.002)	(0.006)	(0.003)	(0.009)
$CASH$	0.008	-0.001	0.005	0.013
	(0.005)	(0.009)	(0.005)	(0.013)
RD	-0.080***	-0.037	-0.059***	0.153***
	(0.012)	(0.025)	(0.011)	(0.032)
ROA	0.009	-0.001	0.014	-0.021
	(0.009)	(0.010)	(0.009)	(0.026)
$VROA$	0.024**	-0.028*	0.019*	0.252***
	(0.010)	(0.015)	(0.010)	(0.029)
$DIVER$	0.013**	-0.008	0.004*	-0.028***
	(0.006)	(0.005)	(0.002)	(0.006)
$DIVD$	0.000	-0.001	-0.001	-0.029***
	(0.001)	(0.003)	(0.001)	(0.004)
$SP500$	0.017***	0.043	0.016***	-0.121***
	(0.004)	(0.038)	(0.003)	(0.007)
$ALYST$	-0.004***	-0.009***	-0.002***	-0.010***
	(0.001)	(0.002)	(0.001)	(0.002)
$CLOSE$	0.011	-0.006	0.039***	0.119***
	(0.016)	(0.015)	(0.013)	(0.037)
$Lag(PIN)$				-0.568***
				(0.022)
PRC				0.000***
				(0.000)
MOM				0.044***
				(0.004)
Adj R^2	0.322	0.630		
Obs.	19,362	19,362	19,362	19,362

Panel B: Adjusted Probability of Informed Trading ($AdjPIN$)				
			Simultaneous Equations	
	FM	FE	$AdjPIN$	TIO
	1	2	3	4
TIO	-0.036***	-0.009**	-0.036***	
	(0.003)	(0.004)	(0.002)	
$SIZE$	-0.020***	-0.017***	-0.021***	0.079***
	(0.002)	(0.001)	(0.000)	(0.001)
MTB	-0.002***	0.000	-0.002***	-0.036***
	(0.001)	(0.001)	(0.000)	(0.001)
$TURN$	-0.062***	-0.025***	-0.065***	0.213***
	(0.009)	(0.009)	(0.004)	(0.014)
$Ln(AGE)$	0.000	-0.003	0.000	-0.006***
	(0.001)	(0.002)	(0.001)	(0.002)
LEV	-0.003	0.006	0.003	0.004
	(0.002)	(0.005)	(0.002)	(0.009)
$CASH$	0.000	-0.008	-0.001	0.015
	(0.006)	(0.008)	(0.004)	(0.013)
RD	-0.037**	-0.009	-0.025***	0.180***
	(0.015)	(0.020)	(0.009)	(0.032)
ROA	0.009	0.000	0.016**	-0.021
	(0.010)	(0.008)	(0.007)	(0.026)
$VROA$	0.030**	-0.003	0.022***	0.257***
	(0.011)	(0.013)	(0.008)	(0.029)
$DIVER$	0.011	-0.002	0.005***	-0.027***
	(0.008)	(0.004)	(0.002)	(0.006)
$DIVD$	0.001	0.000	0.002*	-0.028***
	(0.001)	(0.002)	(0.001)	(0.004)
$SP500$	0.009***	0.032***	0.006***	-0.128***
	(0.002)	(0.005)	(0.002)	(0.007)
$ALYST$	-0.002***	-0.005***	-0.001***	-0.010***
	(0.001)	(0.002)	(0.000)	(0.002)
$CLOSE$	0.008	0.004	0.020**	0.097***
	(0.007)	(0.011)	(0.010)	(0.037)
$Lag(AdjPIN)$				-0.582***
				(0.029)
PRC				0.000***
				(0.000)
MOM				0.039***
				(0.004)
Adj R^2	0.281	0.526		
Obs.	19,362	19,362	19,362	19,362

Another major concern is the reverse causality between information asymmetry measures and institutional ownership. It is possible that institutional investors may avoid stocks with a high probability of private information in stock prices. To partially address this concern, a system of simultaneous equations in which the dependent variables are $PIN(AdjPIN)$ and TIO is estimated (columns 3–4). Following

Gompers and Metrick (2001), stock prices (PRC) and cumulative stock returns over the past 12 months (MOM) are added to the TIO equation. Again, the results show that the TIO coefficient remains negative and highly significant in this alternative specification (column 3), and the coefficients on lagged PIN and lagged $AdjPIN$ in the TIO regression (column 4) are significantly negative. This result reinforces the evidence reported earlier that an inverse relationship exists between TIO and information asymmetry.

Overall, this subsection documents evidence in support of Hypothesis 3.1 that institutional ownership is negatively associated with information asymmetry measures. Given the role of institutional investors as documented in prior literature, this finding implies that institutional investors engage in active monitoring that can help enhance a firm's information environment.

3.4.3 Type and Concentration of Institutional Ownership, and Information Asymmetry

This subsection presents the regression results of examining the effects of type and concentration of institutional ownership on information asymmetry. Table 3.4 reports the results from estimating equation (3.11), where all regressions include year and industry dummies, as well as robust standard errors in parentheses. Panel A displays the results when PIN is the dependent variable. Panel B shows the results when $AdjPIN$ is the dependent variable.

Table 3.4: Type and Concentration of Institutional Ownership, and Information Asymmetry

This table reports the results of the following pooled OLS regression:

$$\begin{aligned} INFOR_{i,t} &= \alpha_0 + \alpha_1 CONCENTRATION/TYPE_{i,t-1} \\ &\quad + \gamma' CONTROL_{i,t-1} + e_{i,t}. \end{aligned}$$

The dependent variable is measured by one of the two proxies: PIN (Panel A) and $AdjPIN$ (Panel B), both measured in year t. $CONCENTRATION$ is measured by top-five largest institutional ownership ($TOP5$), institutional blockholdings ($BLOCK$), or institutional ownership concentration ($TIOHHI$). $TYPE$ refers to independent institutional ownership ($INDEP$) or grey institutional ownership ($GREY$), all measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as discussed in Subsection 3.3.2, all measured in year $t-1$. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Panel A: The Probability of Informed Trading (PIN)			
	1	2	3	4
$TOP5$	-0.032***			
	(0.012)			
$BLOCK$		0.008		
		(0.009)		
$TIOHHI$			-0.113***	
			(0.007)	
$INDEP$				-0.047***
				(0.005)
$GREY$				0.011
				(0.009)
$SIZE$	-0.032***	-0.033***	-0.025***	-0.029***
	(0.001)	(0.001)	(0.001)	(0.001)
MTB	-0.002**	-0.001*	-0.003***	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
$TURN$	-0.103***	-0.103***	-0.091***	-0.103***
	(0.012)	(0.012)	(0.011)	(0.012)
$Ln(AGE)$	0.001	0.001	0.002*	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
LEV	-0.002	-0.002	-0.002	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)
$CASH$	0.013**	0.012**	0.018***	0.011*
	(0.005)	(0.005)	(0.006)	(0.006)
RD	-0.056***	-0.058***	-0.043***	-0.053***
	(0.014)	(0.014)	(0.015)	(0.013)
ROA	0.013**	0.014**	0.016**	0.014**
	(0.007)	(0.007)	(0.007)	(0.006)
$VROA$	0.007	0.004	0.020*	0.010
	(0.012)	(0.013)	(0.010)	(0.012)
$DIVER$	0.002	0.002	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)
$DIVD$	0.001	0.001	0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$SP500$	0.020***	0.022***	0.012***	0.018***
	(0.005)	(0.005)	(0.004)	(0.004)
$ALYST$	-0.004***	-0.004***	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
$CLOSE$	0.024*	0.024*	0.029**	0.024*
	(0.013)	(0.013)	(0.013)	(0.012)
Adj. R^2	0.453	0.452	0.474	0.459
Obs.	19,362	19,362	19,362	19,362

Panel B: The Adjusted Probability of Informed Trading ($AdjPIN$)				
	1	2	3	4
$TOP5$	-0.032***			
	(0.012)			
$BLOCK$		0.000		
		(0.004)		
$TIOHHI$			-0.051***	
			(0.005)	
$INDEP$				-0.044***
				(0.003)
$GREY$				0.010
				(0.009)
$SIZE$	-0.023***	-0.023***	-0.020***	-0.021***
	(0.001)	(0.001)	(0.001)	(0.001)
MTB	-0.001**	-0.001**	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
$TURN$	-0.062***	-0.062***	-0.056***	-0.062***
	(0.007)	(0.007)	(0.007)	(0.007)
$Ln(AGE)$	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
LEV	-0.001	-0.001	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)
$CASH$	0.004	0.003	0.006	0.003
	(0.004)	(0.004)	(0.004)	(0.004)
RD	-0.027***	-0.027***	-0.020**	-0.024***
	(0.007)	(0.007)	(0.008)	(0.007)
ROA	0.010	0.010*	0.011*	0.009*
	(0.006)	(0.006)	(0.006)	(0.006)
$VROA$	0.016*	0.015	0.022***	0.018**
	(0.009)	(0.009)	(0.008)	(0.009)
$DIVER$	0.001	0.001	0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$DIVD$	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$SP500$	0.006**	0.007**	0.002	0.005**
	(0.003)	(0.003)	(0.002)	(0.002)
$ALYST$	-0.003***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
$CLOSE$	0.013*	0.013*	0.015**	0.012
	(0.007)	(0.007)	(0.007)	(0.007)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj. R^2	0.418	0.418	0.425	0.423
Obs.	19,362	19,362	19,362	19,362

Column 1 in both panels shows that top-five largest institutional ownership is negatively associated with information asymmetry measures, as indicated by a negative and significant coefficient estimate of TIO. Institutional block ownership, however, does not have an effect on information asymmetry measures, as the coefficient on $BLOCK$ is insignificant (column 2). In column 3, ownership concentration is negatively associated with information asymmetry measures, as shown by a negative and statistically significant coefficient on $TIOHHI$. These results suggest that the alignment effects as a result of monitoring dominate the entrenchment effects so that a negative relationship between institutional ownership concentration and information asymmetry obtains. This finding thus supports Hypothesis 3.2b that institutional ownership concentration is negatively associated with information asymmetry.

In column 4, where institutional ownership is classified by type, the coefficient on $INDEP$ is negative and significant while the $GREY$ coefficient is insignificant, suggesting that independent institutions, unlike grey ones, can have a mitigating effect on information asymmetry. Chen, Goldstein, and Jiang (2007) and Ferreira and Matos (2008) find that independent institutions have much stronger monitoring incentives, unlike grey institutions which are more likely to hold shares without reacting to management action that does not align with the best interests of shareholders. These results thus support Hypothesis 3.3.

3.4.4 Short-term and Long-term Institutional Ownership and Information Asymmetry

This subsection contains the regression analysis of the effect of institutional investment horizon on information asymmetry. Table 3.5 presents the regression results from estimating equation (3.12). Panel A reports the OLS regression results. Panel B reports the firm fixed effects regression results.

In columns 1 and 4, where long-term and short-term institutional ownership are classified based on churn rates, the coefficient on SIO is positive and significant at the 5% level, suggesting a positive effect of short-term institutional ownership on information asymmetry. By contrast, the coefficient on LIO is negative and significant at the 1% level, suggesting that long-term institutional ownership is negatively associated with information asymmetry.

In columns 2 and 5, where long-term and short-term institutional investors are classified according to Bushee's (1998; 2001) criteria, the coefficient on TRA remains positive and significant at the 1% level, while the coefficient on DED remains significant and negative.

In columns 3 and 6, where investment horizon is measured by the volatility of institutional ownership, the results show that the coefficient on $VTIO$ is positive and significant while the coefficient estimate of $ATIO$ is negative and significant.

Taken together, the above results support Hypothesis 3.4. These results imply that short-term institutional investors take advantage of informational superiority to trade for short-term profits, which exacerbates a firm's information environment; long-term institutional investors, by contrast, engage in active monitoring for long-term benefits, which helps ameliorate the firm's information environment.

Overall, this subsection provides evidence that the investment horizon of institutional investors has a significant effect on information asymmetry. Short-term institutional ownership is positively associated with information asymmetry while long-term institutional ownership is negatively correlated with it. These results, which are robust to including controls for firm characteristics, insider trading, and analyst coverage, as well as using different proxies for information asymmetry, provide support for Hypothesis 3.4.

Table 3.5: Short-term and Long-term Institutional Ownership and Information Asymmetry

This table reports the estimates of the following regression:

$$INFOR_{i,t} = \lambda_0 + \lambda_1 TIO^{\text{short}}_{i,t-1} + \lambda_2 TIO^{\text{Long}}_{i,t-1} + \gamma_j CONTROL_{i,t-1} + e_{i,t}.$$

The dependent variable is measured by one of the two proxies: PIN and $AdjPIN$, both measured in year t. TIO_{Short} is short-term institutional ownership, measured in year $t-1$. TIO_{Long} is long-term institutional ownership, measured in year $t-1$. Short-term and long-term institutional ownership are classified according to churn rates of Gaspar et al. (2005) and Yan and Zhang (2009) (columns 1 and 4), Bushee's (1998; 2001) classification (columns 2 and 5), and institutional ownership volatility of Elyasiani and Jia (2010) and Elyasiani et al. (2010) (columns 3 and 6). $CONTROL$ is a vector that contains the same control variables as discussed in Subsection 3.3.2, all measured in year $t-1$. Panel A shows the pooled OLS regression results. Panel B displays the firm fixed effects regression results. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Pooled OLS Regressions

	PIN			$AdjPIN$		
	SIO/LIO	TRA/DED	$VTIO/ATIO$	SIO/LIO	TRA/DED	$VTIO/ATIO$
	1	2	3	4	5	6
TIO^{Short}	0.022***	0.018***	0.014*	0.021***	0.017***	0.003*
	(0.006)	(0.005)	(0.007)	(0.005)	(0.005)	(0.001)
TIO^{Long}	-0.036***	-0.044***	-0.072***	-0.019***	-0.023***	-0.053***
	(0.009)	(0.009)	(0.009)	(0.004)	(0.004)	(0.006)
$SIZE$	-0.029***	-0.029***	-0.028***	-0.021***	-0.021***	-0.019***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
MTB	-0.002***	-0.003***	-0.003***	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$TURN$	-0.094***	-0.095***	-0.095***	-0.056***	-0.056***	-0.057***
	(0.011)	(0.011)	(0.011)	(0.007)	(0.007)	(0.006)
$Ln(AGE)$	0.001	0.002	0.003***	-0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LEV	-0.001	-0.001	-0.002	0.000	0.000	-0.001
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
$CASH$	0.013**	0.012**	0.010*	0.004	0.004	0.002
	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)
RD	-0.053***	-0.053***	-0.047***	-0.024***	-0.025***	-0.020***
	(0.014)	(0.014)	(0.013)	(0.007)	(0.007)	(0.007)
ROA	0.015**	0.013*	0.008	0.011*	0.010*	0.005
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
$VROA$	0.011	0.012	0.016	0.018**	0.019**	0.022***
	(0.012)	(0.012)	(0.011)	(0.009)	(0.009)	(0.008)
$DIVER$	0.002	0.002	0.002	0.001	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
$DIVD$	0.000	0.000	0.001	0.000	0.001	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$SP500$	0.016***	0.016***	0.017***	0.003	0.003	0.004
	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)
$ALYST$	-0.004***	-0.004***	-0.004***	-0.003***	-0.003***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$CLOSE$	0.030**	0.027**	0.014	0.018**	0.016**	0.004
	(0.013)	(0.013)	(0.013)	(0.007)	(0.007)	(0.008)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.459	0.459	0.462	0.422	0.422	0.426
Obs.	19,362	19,362	19,362	19,362	19,362	19,362

Panel B: Firm Fixed Effects Regressions						
	PIN			$AdjPIN$		
	SIO/LIO	TRA/DED	$VTIO/ATIO$	SIO/LIO	TRA/DED	$VTIO/ATIO$
	1	2	3	4	5	6
TIO^{Short}	0.018**	0.022**	0.011*	0.003***	0.011**	0.007*
	(0.009)	(0.011)	(0.005)	(0.001)	(0.006)	(0.004)
TIO^{Long}	-0.027***	-0.025***	-0.007**	-0.014**	-0.012*	-0.007**
	(0.009)	(0.009)	(0.003)	(0.007)	(0.007)	(0.003)
$SIZE$	-0.028***	-0.028***	-0.026***	-0.017***	-0.017***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
MTB	0.001	0.001	0.001	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$TURN$	-0.067***	-0.067***	-0.066***	-0.026***	-0.025***	-0.024***
	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)	(0.009)
$Ln(AGE)$	-0.004	-0.004	-0.003	-0.004	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
LEV	0.003	0.002	0.003	0.006	0.006	0.006
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
$CASH$	0.000	-0.001	0.000	-0.007	-0.007	-0.008
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
RD	-0.037	-0.037	-0.037	-0.008	-0.009	-0.009
	(0.025)	(0.025)	(0.025)	(0.020)	(0.020)	(0.020)
ROA	-0.001	-0.001	-0.002	0.001	0.001	-0.000
	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)
$VROA$	-0.028*	-0.028*	-0.027*	-0.003	-0.003	-0.002
	(0.015)	(0.015)	(0.015)	(0.013)	(0.013)	(0.013)
$DIVER$	-0.008	-0.008	-0.008	-0.002	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
$DIVD$	-0.001	-0.001	-0.001	-0.001	-0.000	-0.000
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
$SP500$	0.042	0.043	0.042	0.030***	0.031***	0.032***
	(0.038)	(0.038)	(0.038)	(0.005)	(0.005)	(0.005)
$ALYST$	-0.009***	-0.009***	-0.009***	-0.005***	-0.005***	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$CLOSE$	-0.004	-0.005	-0.003	0.006	0.005	0.004
	(0.015)	(0.015)	(0.015)	(0.012)	(0.011)	(0.011)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.630	0.630	0.629	0.526	0.526	0.526
Obs.	19,362	19,362	19,362	19,362	19,362	19,362

3.4.5 The Numbers of Institutional Investors and Blockholders, and Information Asymmetry

This subsection contains the regression results of examining the relationship between information asymmetry and the number of institutional investors or blockholders.

Table 3.6 reports the results from estimating the regression equation (3.13). Panel A reports the OLS regression results. Panel B reports the firm fixed effects regression results.

In columns 1 and 3, the coefficient estimates of NOI are negative and statistically significant, suggesting that the number of institutional investors is negatively associated with information asymmetry. However, the number of institutional blockholders has no effect on information asymmetry, as the coefficient estimates of $NBLOCK$, shown in columns 2 and 4, are statistically insignificant. Edmans and Manso (2011) shows that the number of large investors is an important feature in driving both price efficiency and the strength of corporate governance because when these institutions trade competitively, they impound more information into prices and strengthen the threat of disciplinary trading.

Overall, this subsection provides support for Hypothesis 3.5 that the number of institutional investors is negatively associated with information asymmetry, suggesting that institutional investors can induce higher managerial effort through disciplinary trading and ameliorate a firm's information environment.

Table 3.6: The Numbers of Institutional Investors and Blockholders, and Information Asymmetry

This table reports the estimates of the following regression:

$$INFOR_{i,t} = \upsilon_0 + \upsilon_1 NBLOCK/NOI_{i,t-1} + \gamma' CONTROL_{i,t-1} + e_{i,t}.$$

The dependent variable is measured by one of the two proxies: PIN and $AdjPIN$, both measured in year t. NOI is the number of institutional investors, measured in year $t-1$. $NBLOCK$ is the number of institutional blockholders, measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as discussed in Subsection 3.3.2, all measured in year $t-1$. Panel A displays the pooled OLS regression results. Panel B reports the firm fixed effects regression results. Robust standard errors are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Pooled OLS Regressions

	PIN		$AdjPIN$	
	NOI	$NBLOCK$	NOI	$NBLOCK$
	1	2	3	4
$NBLOCK/NOI$	-0.035***	0.004	-0.022***	0.003
	(0.004)	(0.003)	(0.003)	(0.002)
TIO	0.055***	0.017*	0.027***	0.002
	(0.008)	(0.009)	(0.006)	(0.007)
$SIZE$	-0.014***	-0.027***	-0.009***	-0.017***
	(0.002)	(0.002)	(0.002)	(0.001)
MTB	0.000	0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
$TURN$	-0.050***	-0.067***	-0.015*	-0.025***
	(0.011)	(0.011)	(0.009)	(0.008)
$Ln(AGE)$	0.002	-0.004*	0.001	-0.004
	(0.003)	(0.003)	(0.002)	(0.002)
LEV	0.001	0.002	0.005	0.006
	(0.006)	(0.006)	(0.005)	(0.005)
$CASH$	-0.002	0.000	-0.005	-0.004
	(0.009)	(0.009)	(0.007)	(0.007)
RD	-0.020	-0.035	0.001	-0.008
	(0.024)	(0.024)	(0.020)	(0.020)
ROA	-0.007	-0.001	-0.004	0.000
	(0.010)	(0.010)	(0.008)	(0.008)
$VROA$	-0.014	-0.027*	0.006	-0.002
	(0.015)	(0.015)	(0.012)	(0.012)
$DIVER$	-0.008	-0.007	-0.003	-0.002
	(0.005)	(0.005)	(0.004)	(0.004)
$DIVD$	-0.001	-0.001	0.000	0.000
	(0.003)	(0.003)	(0.002)	(0.002)
$SP500$	0.041	0.043	0.030***	0.032***
	(0.034)	(0.038)	(0.005)	(0.005)
$ALYST$	-0.006***	-0.009***	-0.003*	-0.004***
	(0.002)	(0.002)	(0.002)	(0.002)
$CLOSE$	0.001	-0.004	0.007	0.004
	(0.014)	(0.014)	(0.010)	(0.011)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj. R^2	0.639	0.633	0.552	0.548
Obs.	19,362	19,362	19,362	19,362

Panel B: Firm Fixed Effects Regressions				
	PIN		$AdjPIN$	
	NOI	$NBLOCK$	NOI	$NBLOCK$
	1	2	3	4
$NBLOCK/NOI$	-0.059***	0.005	-0.035***	0.007
	(0.003)	(0.004)	(0.002)	(0.006)
TIO	0.030***	-0.052***	0.018***	-0.039***
	(0.008)	(0.011)	(0.003)	(0.005)
$SIZE$	-0.000	-0.028***	-0.003***	-0.020***
	(0.002)	(0.002)	(0.001)	(0.001)
MTB	-0.005***	-0.002***	-0.003***	-0.002***
	(0.001)	(0.001)	0.000	(0.001)
$TURN$	-0.071***	-0.093***	-0.042***	-0.054***
	(0.008)	(0.011)	(0.005)	(0.006)
$Log(AGE)$	0.006***	0.001	0.002***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
LEV	0.000	-0.001	0.001	0.000
	(0.004)	(0.005)	(0.003)	(0.004)
$CASH$	0.014**	0.011**	0.004	0.003
	(0.006)	(0.005)	(0.004)	(0.003)
RD	-0.015	-0.051***	-0.001	-0.023***
	(0.014)	(0.014)	(0.008)	(0.007)
ROA	-0.001	0.013**	0.001	0.009*
	(0.006)	(0.006)	(0.005)	(0.005)
$VROA$	0.035***	0.013	0.033***	0.019**
	(0.009)	(0.011)	(0.007)	(0.008)
$DIVER$	0.001	0.002	0.000	0.001
	(0.003)	(0.003)	(0.002)	(0.002)
$DIVD$	0.002	0.000	0.002	0.001
	(0.002)	(0.002)	(0.001)	(0.002)
$SP500$	0.017***	0.017***	0.004*	0.004
	(0.004)	(0.005)	(0.002)	(0.002)
$ALYST$	-0.003***	-0.004***	-0.002***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
$CLOSE$	0.019	0.026**	0.008	0.013*
	(0.012)	(0.012)	(0.007)	(0.007)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj. R^2	0.510	0.470	0.469	0.444
Obs.	19,362	19,362	19,362	19,362

3.5 Conclusions

This study uses the PIN measure of Easley et al. (2002) and the $AdjPIN$ measure of Duarte and Young (2009) as proxies for information asymmetry to examine the effects of the different dimensions of institutional investor heterogeneity on a firm's information environment.

This study finds a negative effect of institutional ownership on information asymmetry that is robust to the use of controls for firm characteristics, insider trading, and analysis coverage, as well as different estimation methods. These results imply that institutional investors can help enhance a firm's information environment.

Because institutional investors are heterogeneous in several aspects, this study disaggregate institutional ownership into distinct types and finds that short-term institutional ownership is positively associated with information asymmetry, while top-five largest institutional ownership, institutional ownership concentration, independent institutional ownership, long-term institutional ownership, and the number of institutional investors have negative effects on information asymmetry. Overall, this study highlights the importance of the heterogeneity of institutional investors in shaping a firm's information environment.

Chapter 4

Institutional Investors, Information Asymmetry, and Expected Stock Returns

4.1 Introduction

Although traditional asset pricing theories (e.g., Fama, 1970, 1991) assume that information risk has no pricing effect on expected returns because it is completely diversifiable, an influential set of papers (e.g., Easley et al., 2002; Easley and O'Hara, 2004) claims that information risk that arises from information asymmetry between informed and uninformed traders is systematic and thus undiversifiable. Easley, Hvidkjaer, and O'Hara (2002) develop the well-known measure of informed trading, called PIN (probability of informed trading), and find that stocks with higher PINs tend to have higher returns. In a subsequent study, Easley and O'Hara (2004) develop a theoretical microstructure model that predicts that investors require a higher return to hold a stock with a greater probability of informed trading. This higher return is necessary because, while informed investors are better able to shift their portfolios to incorporate new information, uninformed investors cannot and thus are at a disadvantage. To date, numerous empirical studies in both finance and accounting have found support for PIN as a proxy for priced information risk. [1]

Despite its widespread empirical application, PIN has recently been subjected to considerable skepticism over whether it truly captures priced information risk. For instance, Hughes, Liu, and Liu (2007) and Lambert, Leuz, and Verrecchia (2007) find that information risk is either diversifiable or subsumed by existing risk factors. Mohanram and Rajgopal (2009) find that the relation between PIN and expected returns is not robust to alternative specifications and time periods, which casts doubt on whether PIN is a priced risk factor. One study that warrants special attention in this thesis is Duarte and Young (2009), which examines whether PIN is priced because of information asymmetry or because of the other illiquidity effects that are unrelated to information asymmetry for a sample of stocks listed on

[1] See Appendix A of Mohanram and Rajgopal (2009) for a detailed list of references.

the U.S. equity markets. Decomposing PIN into two components—illiquidity and asymmetric information—the latter of which is termed $AdjPIN$ (adjusted PIN) because it is a PIN measure purged of illiquidity effects, these authors find that while the illiquidity component of PIN is priced, the asymmetric information component is not. They thus conclude that the well documented relation between PIN and expected returns is actually due to illiquidity effects unrelated to information asymmetry. Recently, Lai, Ng, and Zhang (2014) has used rich international data from 47 countries and reinforced Duarte and Young's (2009) evidence from a global perspective.

This study examines how the information asymmetry that is captured by PIN and $AdjPIN$ affects expected returns under a circumstance in which information asymmetry is likely to be in evidence. The question at issue is not as much about whether PIN and $AdjPIN$ adequately capture information asymmetry, but more about the circumstance under which information asymmetry does matter to asset pricing. This study investigates how institutional investors affect the relationship between information risk and expected returns, and hypothesize that the pricing effect of information asymmetry should be high (low) for stocks with low (high) levels of institutional ownership.

There are two main explanations for why the roles of institutional investors should be considered when examining the pricing effect of information asymmetry. First, extant literature has documented that one potential role of institutional investors is to act as a credible mechanism for transmitting information to other market participants (Stepanyan, 2011). Given that institutional investors are likely to have superior information due to the economy of scale in information acquisition and processing, the market may interpret institutional investor equity ownership as a credible signal that conveys information about a firm's performance and prospects. Second, prior research has demonstrated that despite free-rider problems, institutional investors have much stronger incentives to monitor companies that they own than do other investors because of their larger stakes in those companies, especially if exit is costly (i.e., large trading costs). Therefore, institutional investor stock equity ownership may signal that the severity of information asymmetry in the firm is likely to be mitigated by intensive institutional monitoring.

Based on these arguments, this study hypothesizes that institutional ownership should affect the pricing effect of information risk as captured by PIN and $AdjPIN$. Using both the portfolio approach and the regression framework of Fama and MacBeth (1973), this study finds that although there is a pricing effect of information risk, this relationship holds only for a subset of sample stocks, that is, stocks that have low levels of institutional ownership; however, there is no such evidence for stocks with high institutional ownership levels. These findings suggest that uninformed investors only command a premium for holding stocks of those firms in which information asymmetry is most likely to be in evidence.

Overall, this study contributes to the literature by shedding light on how institutional investors can alter the relation between information risk and expected returns. The results suggest that the empirical controversy over the pricing effect of information asymmetry captured by PIN and $AdjPIN$ should be illuminated under a circumstance in which information asymmetry matters much to asset pricing. The market appears to be less concerned about information risk of a firm's stock if it has high levels of institutional ownership, suggesting that investors only require compensation for information risk to hold stocks with low institutional ownership levels.

The remainder of this chapter is organized as follows. Section 4.2 discusses literature review and hypothesis development. Section 4.3 discusses data, variables, and methodology. Section 4.4 presents empirical results. Section 4.5 concludes.

4.2 Literature Review and Hypothesis Development

The seminal work of Fama (1970, 1991) on efficient markets assumes that information risk, which is potentially idiosyncratic and thus diversifiable, has no effect on expected returns. However, a large body of literature, represented by an influential set of papers by Easley and O'Hara, has argued that information risk that originates from information asymmetry between uninformed and informed traders is systematic, undiversifiable, and thus priced. Easley and O'Hara (2004) develop a microstructure model of a world characterized by incomplete information in which a market maker confronts both informed and uninformed traders. The model predicts that investors require a premium to hold stocks with a greater probability of private information because the higher return compensates uninformed investors for their tendency to overweight stocks with undisclosed bad news and underweight stocks with undisclosed good news. In subsequent theoretical work, Lambert, Leuz, and Verrecchia (2011) argue that imperfect competition produces a differential impact of private information on prices, and this impact is stronger for illiquid stocks.

Empirically, Easley, Hvidkjaer, and O'Hara (2002) develop their well-known PIN measure and find that stocks with a higher PIN tend to have a higher return. A large body of empirical research has adopted PIN as the principal proxy for information asymmetry and found that information risk is systematically priced by investors. For example, Easley, Hvidkjaer, and O'Hara (2010) find that PIN remains an important determinant of asset returns even in the presence of the Fama-French, momentum, and liquidity factors. Li et al. (2009) find a strong positive relationship between information risk and expected Treasury bond returns. Armstrong et al. (2011) find that expected returns are increasing in the degree of adverse selection when there is a relatively low degree of market competition. Duarte et al. (2008) find that changes in a firm's information environment are significantly related to its cost of capital.

Berkman, Koch, and Westerholm (2014) devised a novel measure of the probability of informed trading called $BABYPIN$—the proportion of total trading through the accounts of underaged investors—and find that information risk is priced in the cross section of stock returns, which is consistent with Easley and O'Hara (2004).

Of late, however, a small but growing strand of literature has casted doubt on whether PIN captures information risk. Hughes, Liu, and Liu (2007) study the role of information risk in a multi-factor asset pricing model and find that information risk is either diversifiable or subsumed by existing risk factors. Aktas et al. (2007) examine the behavior of PIN around a sample of merger and acquisition announcements made on Euronext Paris between 1995 and 2000 and find that it appears to be in contradiction with clear evidence of information leakages in their sample during the pre-event period. Hughes, Liu, and Liu (2007) and Lambert, Leuz, and Verrecchia (2007) argue that under perfect competition, information risk is diversifiable and thus is not priced. Mohanram and Rajgopal (2009) find that the pricing effect of PIN is restricted to a certain period and model specification only.

One study that receives considerable attention in this thesis is Duarte and Young (2009), which examines why the empirical evidence on PIN does not agree with the traditional asset pricing theory that predicts that information risk is idiosyncratic and diversifiable. Extending the PIN model by decomposing PIN into two components—illiquidity and asymmetric information—they find that the pricing effect of information asymmetry as captured by PIN is actually driven by the illiquidity effects that are unrelated to asymmetric information. Using the Fama and MacBeth (1973) regression that includes $AdjPIN$ as a proxy for asymmetric information, they find that $AdjPIN$ is orthogonal to expected returns and thus conclude that PIN is priced not because it is a proxy for information asymmetry. The recent work of Lai, Ng, and Zhang (2014) has reinforced this evidence in an international setting based on rich data from 47 countries. Overall, the existing research makes competing claims over whether information risk is priced in the cross section of stock returns.

This study argues that the pricing effect of information risk that originates from information asymmetry and is captured by the PIN measure of Easley, Hvidkjaer, and O'Hara (2002) and the $AdjPIN$ measure of Duarte and Young (2009) should be clearer in a circumstance under which information asymmetry is most likely to be in evidence. Specifically, this study conjectures that institutional investors should affect the relationship between information risk and expected returns because of their monitoring and informational roles.

One body of literature has documented that institutional investors are better able to provide effective and active monitoring because of their large ownership stakes in the firms. Institutional investors can monitor through direct intervention by correcting managerial inefficiency or by engaging in implementing profitable projects (Gillan and Starks, 2000; Hartzell and Starks, 2003; Shleifer and Vishny, 1986). They can also monitor to influence managerial decisions through threats of exit or sales of their shareholdings, which could depress the firm's stock price because they typically hold large positions in a firm (Admati and Pfleiderer, 2009; Edmans, 2009; Edmans and Manso, 2011; Parrino, Sias, and Starks, 2003).

A related strand of literature has documented that compared to other investors, institutional investors possess informational advantages owning to their ability to exploit the economy of scale in information production and processing. Chidambaram and John (1998) find that institutional investors can convey private information that they obtain from management to other shareholders. Gompers and Metrick (2001) find that institutional ownership conveys information about stock returns. Bushee, Matsumoto, and Miller (2004) find that firms with greater institutional ownership are less likely to have conference calls, suggesting that institutional investors can produce information and thus reduce the need for conference calls. Bushee and Goodman (2007) find that changes in ownership by institutions with large positions in a firm are positively associated with that firm's future earnings. Chiang, Qian, and Sherman (2010) document that stock returns are higher when more institutional investors enter the auction or bid higher prices in Taiwan's IPO market.

These two related strands of literature imply that the presence of institutional investors may send credible information signals to the market as well as mitigating information asymmetry. For instance, institutional investors can directly intervene by pressing a firm to disclose information in a timely manner, which makes its stock price more informative about the fundamental value. Healy, Hutton, and Palepu (1999) provide support for this argument by documenting a positive association between institutional ownership and financial analysts' ratings of overall corporate disclosure practices. Velury and Jenkins (2006) document that institutional ownership is positively associated with earnings qualities. Therefore, the presence of institutional investors in a firm through stock equity ownership may signal that the severity of information asymmetry in that firm is likely to be mitigated by intensive institutional monitoring. Moreover, the market may interpret the presence of institutional investors in a firm in the form of equity ownership as a credible signal that conveys information about the firm's performance and prospects; hence the risk premium that uninformed investors require for bearing information risk should be smaller under this circumstance.

Based on the above discussion, the following hypothesis can be formulated:

Hypothesis 4.1: *The pricing effect of information risk as captured by PIN and $AdjPIN$ exists (disappears) among stocks with low (high) levels of institutional ownership.*

4.3 Data, Variables, and Methodology

4.3.1 Data

This study begins with all publicly traded firms on the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX) for the 1993–2007 period. This sample period is selected to overlap largely with those of Duarte and Young (2009) and Easley, Hvidkjaer, and O'Hara (2010).[2] Stock return, share price, shares outstanding, and firm age are obtained from the Center for Research in Security Prices (CRSP). Insider transactions and institutional holdings are obtained from the Thomson Reuters ownership database. Firm characteristics are obtained from Compustat. Analyst coverage is from the Institutional Brokers Estimate System (I/B/E/S).

To estimate PIN and $AdjPIN$, data on trades and quotes are obtained from the Trade and Automated Quote (TAQ) database. Following prior literature, financial companies (SIC 6000–6999), utilities (SIC 4900–4999), American Depository Receipts (ADRs), Real Estate Investment Trusts (REITs), companies incorporated outside of the U.S., and closed-end funds are excluded, as is any stock that has fewer than 60 days of quotes or trades in any sample year because it is impossible to estimate the PIN and $AdjPIN$ models reliably based on such a stock (Easley, Hvidkjaer, and O'Hara, 2010). Trades and quotes that occur before and at the open, and at and after the close, quotes that have zero bids and/or ask prices, and trades that have zero prices are all excluded. Finally, observations with missing stock returns or accounting data are also excluded. All variables are winsorized at the top and bottom 1% tails to eliminate the effects of outliers. The final sample consists

[2] This choice is more appropriate for the debate on the pricing effect of information asymmetry as captured by PIN and $AdjPIN$, because Mohanram and Rajgopal (2009) are concerned that the effect of information asymmetry captured by PIN on expected returns is restricted to a certain period only.

of 3,782 firms with 19,362 firm-year observations.

4.3.2 Variables

PIN and AdjPIN

As the most widely used proxy for information asymmetry, PIN originates from the theoretical market microstructure model of Easley et al. (1996). To date, a large body of research has adopted PIN as the principal measure to examine the pricing of information asymmetry.[3] The PIN model of Easley et al. (1996) is based on the sequential trade models of Glosten and Milgrom (1985) and Easley and O'Hara (1987) in which orders come from either informed traders who trade for speculative purposes based on private information, or uninformed (noise) traders whose reasons for trading are exogenous. The model assumes that there is an uninformed liquidity provider who sets bid and ask quotes by observing the flows of buy and sell orders and assessing the probability that these orders come from informed traders. The bid-ask spread compensates the liquidity provider for the possibility of trading with informed traders. At the beginning of each trading day, the arrival rate of buy (sell) orders follows the independent Poisson distribution. The likelihood function of the Easley et al. (1996) model is as follows:

$$\begin{aligned} L(a,d,u,\varepsilon_b,\varepsilon_s|B,S) &= (1-a)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \\ &\quad +ade^{-(u+\varepsilon_b)}\frac{(u+\varepsilon_b)^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \\ &\quad +a(1-d)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-(u+\varepsilon_s)}\frac{(u+\varepsilon_s)^S}{S!}, \end{aligned} \tag{4.1}$$

[3] See, for example, Easley and O'Hara (2004), Hughes, Liu, and Liu (2007), Easley, Hvidkjaer, and O'Hara (2002), Hail and Leuz (2006), Easley, Hvidkjaer, and O'Hara (2010), Duarte and Young (2009), Duarte et al. (2008), Chen, Goldstein, and Jiang (2007), Ferreira, Ferreira, and Raposo (2011), Aktas et al. (2007), and Benos and Jochec (2007), among others.

where $B(S)$ is the numbers of buys (sells) for a given trading day, a is the probability of a private information event occurring before the day, d and $(1-d)$ are the probabilities of good news and bad news, respectively, if the information event occurs, u is the arrival rate of buy or sell orders submitted by informed traders, and $\varepsilon_b(\varepsilon_s)$ is the arrival rate of buy (sell) orders submitted by uninformed traders. With the structural parameters estimated by maximizing the log-likelihood function based on (4.1), [4] Easley, Hvidkjaer, and O'Hara (2002) compute PIN as a fraction of orders that arises from informed trades relative to the overall order flow, as follows:

$$PIN = \frac{au}{au + \varepsilon_s + \varepsilon_s}. \tag{4.2}$$

This study estimates PIN for a sample of all ordinary common stocks listed on the NYSE and AMEX (CRSP exchange codes 1 and 2, and share codes 10 and 11) for the years 1993–2007, using intraday trades and quotes of stocks collected from the TAQ database. Only the NYSE and AMEX stocks are selected because these exchanges possess the market microstructure that conforms most closely to the PIN structural model. The Lee and Ready (1991) algorithm is used to classify buy-initiated trades (buys) and sell-initiated trades (sells). Trades with a price above the midpoint of the bid-ask spread five seconds before the trades are classified as "buys" and those below the midpoint as "sells". Trades that occur at the mid-point of the bid and ask prices are classified as buyer- or seller-initiated according to a tick test, which classifies a trade as buyer-initiated (sell-initiated) if the price is above (below) that of the previous trade. If there are no quotes posted during the trading day, the tick test is used to sign any trades made during the day. For each stock on each day, the total number of buys and sells are then aggregated.

While PIN is commonly adopted as a measure of information asymmetry, a small

[4] Following Easley, Hvidkjaer, and O'Hara (2010), the common term $e^{-\varepsilon_b-\varepsilon_s}\frac{(u+\varepsilon_s)^B(u+\varepsilon_s)^S}{B!S!}$ from (4.1) is factored out because computing the factorial and exponential of a large number of buy and sell orders is likely to cause numerical overflows.

but growing stream of research has casted doubt on whether it even captures information risk that arises from information asymmetry. In particular, Duarte and Young (2009) argue that when PIN is decomposed into two components, namely, illiquidity and asymmetric information, the component related to information asymmetry, i.e., $AdjPIN$, is not priced in the cross section of stock returns. Duarte and Young (2009) design the $AdjPIN$ measure to cope better with the pervasive positive contemporaneous correlation between buys and sells as observed in the data. In this study, $AdjPIN$ is used as the second proxy for information asymmetry, which is computed based on Duarte and Young (2009), as follows:

$$AdjPIN = \frac{a(du_b + (1-d)u_s)}{a(du_b + (1-d)u_s) + (\Delta_b + \Delta_s)(a\theta' + (1-a)\theta) + \varepsilon_b + \varepsilon_s}, \tag{4.3}$$

where the parameters in (4.3) are derived from Duarte and Young's (2009) $AdjPIN$ model, $\theta(\theta')$ is the probability of a symmetric order-flow shock conditional on the absence (arrival) of private information, $\Delta_b(\Delta_s)$ is the arrival rate of buys (sells) caused by symmetric order-flow shocks, and $u_b(u_s)$ is the arrival rate of buy (sell) orders submitted by informed traders if the information event occurs. The definitions of $\varepsilon_b, \varepsilon_s, a$, and d are the same as in (4.1).

The $AdjPIN$ measure differs from PIN in several ways. First, $AdjPIN$ allows for the arrival rate of informed buyers, u_b, to be different from the arrival rate of informed sellers, u_s, which enables the model to account for the fact that the buy order flow has a much greater variance relative to sell order flow for virtually all firms in the data. The more important difference is that the $AdjPIN$ model allows for a new type of arrival rates of buys (sells) in the event of symmetric order-flow shocks, i.e., $\Delta_b(\Delta_s)$.

This study follows Duarte and Young (2009) to estimate the $AdjPIN$ measure for each firm-year over the 1993–2007 period by setting $\theta = \theta'$. To avoid numerical overflows, the term $e^{(-\lambda+X\ln(\lambda)-\sum_{i=1}^{X} i)}$ is used for the Poisson density function of the form $e^{-\lambda}\frac{\lambda^X}{X!}$. As with PIN, the common term in the joint probability density function is factored out.

Institutional Ownership

Institutional ownership (TIO) is defined as the sum of shares held by all institutional investors as a fraction of the firm's total shares outstanding, measured at the end of each year. Following prior work (e.g., Gompers and Metrick, 2001; Yan and Zhang, 2009), stocks with TIO greater than 100% are all excluded, and the TIO of any stock that is not held by any institution is set to zero.

Abnormal Stock Returns

As in prior work (e.g., Armstrong et al., 2011), this study estimates abnormal returns (alphas) using the four-factor model of Carhart (1997). The next subsection provides details of how a hedge portfolio is constructed and how its abnormal return is estimated.

Control Variables

To follow existing literature (Ferreira and Laux, 2007; Piotroski and Roulstone, 2004), this study uses the following control variables:

- Firm size ($SIZE$): Firm size is defined as the natural logarithm of market capitalization ($MCAP$), where $MCAP$ is calculated as share price times shares outstanding at the end of the fiscal year. Both share price and shares outstanding are corrected for stock splits and dividends using the CRSP cumulative adjustment factors.

- Firm age ($Ln(AGE)$): This variable is defined as the natural logarithm of the number of years (AGE) since first return appears in CRSP.
- Market-to-Book ratio (MTB): This variable is defined as the market value over the book value of equity at the end of the fiscal year.
- Turnover ($TURN$): This variable is the average monthly share trading volume over total shares outstanding over the past twelve months.
- Leverage (LEV): This variable is defined as the ratio of current and long-term debt to the book value of total assets at the end of the fiscal year.
- Return on assets (ROA): This variable is calculated as the ratio of operating income before depreciation, interest, and extraordinary items to the book value of total assets at the end of the fiscal year.
- Volatility of return on assets ($VROA$): This variable is calculated as the standard deviation of ROAs scaled by the book value of total assets over the preceding three years.
- Dividend dummy ($DIVD$): This dummy equals one if a firm pays cash dividends during the fiscal year and zero otherwise.
- Diversification dummy ($DIVER$): This dummy equals one if a firm is a multi-segment corporation and zero otherwise.
- S&P 500 membership ($SP500$): This dummy equals one if the stock is a member of the S&P 500 index and zero otherwise.
- Analyst coverage ($ALYST$): Analysts disseminate private information through their earnings forecasts, revisions and stock recommendations. Piotroski and Roulstone (2004) find that analysts increase the relative amount of market- and industry-level information reflected in stock prices, which suggests that analysts are likely to reduce private information in stock prices. Following prior work, analyst coverage is defined as the natural logarithm of the number

of analysts following a firm during each fiscal year and set to zero if there is no information on the number of analysts.

- Insider trading ($CLOSE$): Insiders transmit private information to other market participants through their trading activity (Chen, Goldstein, and Jiang, 2007; Piotroski and Roulstone, 2004; Sias and Whidbee, 2010). Following Sias and Whidbee (2010), insider trading is measured as the difference between the number of shares purchased and the number of shares sold by insiders, scaled by the total number of shares outstanding at the end of the fiscal year.

4.3.3 Methodology

The focus of this study is to examine how institutional ownership affects the relationship between information asymmetry and expected stock returns. Before tackling this research question, the relationship between institutional ownership and information asymmetry is examined by estimating the following regression:

$$INFOR_{i,t} = \beta_0 + \beta_1 TIO_{i,t-1} + \gamma' CONTROL_{i,t-1} + e_{i,t}, \tag{4.4}$$

where the dependent variable is proxied by either PIN or $AdjPIN$, both measured in year t. The key independent variable is TIO, measured in year $t-1$. $CONTROL$ is a vector of firm characteristics as discussed in Subsection 4.3.2 and measured in year $t-1$. Subscripts i and t index stock and year, respectively.

To examine the pricing effect of information asymmetry as measured by PIN and $AdjPIN$, this study uses both the portfolio approach and the Fama and MacBeth's (1973) regression framework. The portfolio approach is used to compare the abnormal return of a portfolio of large-PIN (large-$AdjPIN$) stocks with that of a portfolio of small-PIN (small-$AdjPIN$) stocks. This approach is used because of the advantage that it frees researchers from the assumption of linearity in the variable of interest (e.g., the sort variable); besides, this approach collapses the cross section of returns into a single time series observation and thus alleviates concerns over the cross-sectional dependence. At the end of each year, sample stocks are sorted into terciles based on the PIN ($AdjPIN$) measure estimated over the year. Then for each of these portfolios, both the monthly equally weighted and value-weighted portfolio returns are computed, with the value-weighted returns calculated based on the market capitalization measured during the previous month. Next, a hedge portfolio is formed by taking a long position in the large-PIN (large-$AdjPIN$) portfolio and a short position in the small-PIN (small-$AdjPIN$) portfolio. Finally, the abnormal return of the hedge portfolio is computed by estimating the following four-factor model of Carhart (1997):

$$\begin{aligned} R_t^{\text{hedge}} &= \alpha_{\text{INFO}} + \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t \\ &\quad + \beta_4 UMD_t + e_t, \end{aligned} \tag{4.5}$$

where the dependent variable is the monthly return of the hedge portfolio, $MKTRF$, SMB, and HML are the three factors of Fama and French (1993), and UMD is the momentum factor of Carhart (1997). The variable of interest, α_{INFO}, refers to either α_{PIN} or α_{AdjPIN} depending on whether the portfolio is sorted by PIN or $AdjPIN$. A positive and significant coefficient on α_{INFO} suggests that a trading strategy of buying large-PIN (large-$AdjPIN$) stocks and selling small-PIN (small-$AdjPIN$) stocks is profitable, thus implying that investors generally require compensation for information risk arising from information asymmetry.

To address the main research question of how institutional ownership affects the pricing effect of information asymmetry, this study first uses the portfolio approach in which the sample stocks are double-sorted by TIO and PIN ($AdjPIN$). Double-sorting makes it possible to see whether there are significant differences in the abnormal returns of the hedge portfolios across different TIO-sorted groups. Specifically, stocks are sorted into quintiles based on TIO measured at the end of the year. The stocks in each quintile portfolio are then sorted into terciles according to PIN ($AdjPIN$) estimated over the year. Double-sorting thus produces fifteen $TIO-PIN$ ($TIO - AdjPIN$) portfolios as shown below:

TIO \ $PIN/AdjPIN$	Small (A)	Medium (B)	Large (C)	Hedge Portfolio (C–A)
Lowest (1)	(1,A)	(1,B)	(1,C)	(1,C)–(1,A)
(2)	(2,A)	(2,B)	(2,C)	(2,C)–(2,A)
(3)	(3,A)	(3,B)	(3,C)	(3,C)–(3,A)
(4)	(4,A)	(4,B)	(4,C)	(4,C)–(4,A)
Highest (5)	(5,A)	(5,B)	(5,C)	(5,C)–(5,A)

For each of the five TIO-sorted portfolios, a hedge portfolio is constructed by longing the largest-PIN (largest-$AdjPIN$) stocks and shorting the smallest-PIN (smallest-$AdjPIN$) stocks, resulting in five hedge portfolios. The abnormal return (α_{INFO}) of a hedge portfolio is computed by estimating equation (4.5). Checking the statistical and economic significance of α_{INFO} across the TIO-sorted quintile groups will reveal settings in which institutional ownership affects the pricing of information asymmetry.

In the second approach based on the Fama and MacBeth's (1973) regression framework, this study estimates the following regression model:

$$\begin{aligned} R_{i,t} \;=\; & \beta_0 + \beta_1 INFO_{i,t-1} + \beta_2 BETA_{i,t-1} + \beta_3 SIZE_{i,t-1} \\ & + \beta_4 BTM_{i,t-1} + e_{i,t}, \end{aligned} \tag{4.6}$$

where the dependent variable is the monthly return of stock i, $INFO$ is proxied by either PIN or $AdjPIN$, both measured in month $t-1$. $BETA$ is the beta of the stock in month $t-1$ and is estimated using data of the past 60 months. $SIZE$ and

BTM are firm size and book-to-market ratio, respectively, both measured in month $t-1$.

To examine whether institutional ownership affects the pricing effect of information asymmetry, equation (4.6) is augmented by including interaction terms between PIN ($AdjPIN$) and dummy variables for TIO groups. Specifically, stocks are first sorted into terciles based on TIO measured at the end of each year, and three dummy variables are used to index the group to which a stock belongs. These binary variables are then interacted with PIN ($AdjPIN$) for use in the following regression:

$$\begin{aligned} R_{i,t} &= \beta_0 + \beta_1(INFO_{i,t-1} \times DL) + \beta_2(INFO_{i,t-1} \times DM) \\ &\quad + \beta_3(INFO_{i,t-1} \times DH) + \beta_4 DM + \beta_5 DH + \beta_6 BETA_{i,t-1} \\ &\quad + \beta_7 SIZE_{i,t-1} + \beta_8 BTM_{i,t-1} + e_{i,t}. \end{aligned} \tag{4.7}$$

The advantage of this regression framework is that it concurrently controls for size and book-to-market that may be correlated with institutional ownership. The key variables are the three interaction terms, $(INFO \times DL)$, $(INFO \times DM)$, and $(INFO \times DH)$, where DL is a dummy variable that equals one if the stock belongs to the groups of stocks with low TIO, DM to the group of stocks with medium TIO, and DH to the group of stocks with high TIO. The interaction terms capture the differential pricing effect of information asymmetry for stocks in the different TIO-sorted groups.

A positive and significant coefficient estimate of the interaction term $(INFO \times DL)$ suggests that the pricing effect of information asymmetry is significant only for stocks with low institutional ownership levels. Similarly, if the coefficient on $(INFO \times DH)$ is insignificant, there is no evidence of such a pricing effect on stocks with high levels of institutional ownership.

Although this study focuses specifically on the PIN and $AdjPIN$ as measures of private information-based trading, it should be pointed out that both of these measures are not without weaknesses. A theoretical objection against PIN is that this measure is based on assumptions which are not really realistic. For instance, information events may not be independent across days, or informed traders may not trade on their private information on the same day that they acquired it. Additionally, good news or bad news might arrive over a sequence of days, after which there is a complete absence of news over another sequence of days. As a result, recent empirical and theoretical studies provide results that challenge the evidence that asymmetric information risk embodied in PIN has a pricing effect (Benos and Jochec, 2007; Duarte and Young, 2009; Hughes et al., 2007; Lai et al., 2014; Lambert et al., 2007). In a recent study, Berkman et al. (2014) derived a clever, novel measure of private information-based trading, called $BABYPIN$, which measures the proportion of total trading activity through underaged accounts, and find that it serves as an effective proxy for the probability of information-based trading in a stock.

4.4 Empirical Results

4.4.1 Univariate Analysis

The summary statistics on cross-sectional information asymmetry measures, institutional ownership, and firm characteristics are computed for each year over the 1993–2007 period. Table 4.1 reports the time-series mean, median, standard deviation, 25th quartile, and 75th quartile of these cross-sectional averages. The mean and median value of PIN is 0.20 and 0.17, respectively, which suggests that about 20% of all observed trades in the sample originate from informed investors. Compared with PIN, the mean and median of $AdjPIN$ are smaller (0.17 and 0.15, respectively), which is consistent with Duarte and Young's (2009) finding that $AdjPIN$ captures only the asymmetry information component of PIN. The average institutional ownership is 59% over the sample period. The average firm has a market capitalization of \$2.6 billion, about 12 years of CRSP return data, an ROA of 9%, and a leverage ratio of 26%. Its turnover rate and market-to-book ratio are 9.0% and 1.98, respectively.

Table 4.1: Summary Statistics

This table reports the time-series mean, median, standard deviation, and 25th and 75th quartiles of all variables for the 1993–2007 sample period. Data are from the CRSP, Compustat, I/B/E/S, TAQ, and Thomson Reuters databases.

	Firms	**Firm-Years**	**Mean**	**Std**	**Q1**	**Median**	**Q3**
PIN	3,782	19,362	0.201	0.102	0.132	0.175	0.239
$AdjPIN$	3,782	19,362	0.165	0.077	0.113	0.148	0.199
TIO	3,782	19,362	0.592	0.284	0.244	0.522	0.721
$MCAP$	3,782	19,362	2.501	7.379	0.088	0.407	1.489
MTB	3,782	19,362	1.981	1.523	1.144	1.497	2.156
$TURN$	3,782	19,362	0.094	0.129	0.026	0.056	0.110
AGE	3,782	19,362	12.383	1.130	6.209	12.420	12.526
LEV	3,782	19,362	0.263	0.217	0.086	0.239	0.383
$CASH$	3,782	19,362	0.103	0.183	0.017	0.054	0.159
RD	3,782	19,362	0.033	0.079	0.000	0.000	0.029
ROA	3,782	19,362	0.094	0.185	0.069	0.123	0.176
$VROA$	3,782	19,362	0.096	0.170	0.073	0.123	0.175
$DIVER$	3,782	19,362	0.909	0.287	1.000	1.000	1.000
$DIVD$	3,782	19,362	0.475	0.499	0.000	0.000	1.000
$SP500$	3,782	19,362	0.068	0.252	0.000	0.000	0.000
$ALYST$	3,782	19,362	4.342	2.284	1.000	3.751	20.303
$CLOSE$	3,782	19,362	0.014	0.049	0.000	0.000	0.005

Table 4.2 shows key characteristics of the fifteen portfolios double-sorted by TIO and PIN ($AdjPIN$). The key characteristics include the average of PINs ($AdjPIN$s), TIOs, and monthly returns. Several remarks are in order. First, both PIN and $AdjPIN$ decrease monotonically from the lowest- to the highest-TIO stocks. Second, TIO decreases slightly from small- to large-PIN (large-$AdjPIN$) stocks within each TIO quintile group. Apparently, there is an inverse relationship between TIO and information asymmetry as proxied by PIN and $AdjPIN$. While the monthly return appears to depend on TIO and information asymmetry, the difference in monthly returns between the large-PIN (large-$AdjPIN$) and small-PIN (small-$AdjPIN$) portfolios is positive and statistically significant only for the lowest- and second lowest-TIO quintiles.

Table 4.2: Summary Statistics for Portfolios Double-Sorted by TIO and PIN ($AdjPIN$)

This table displays key characteristics of portfolios double-sorted by TIO and PIN ($AdjPIN$) for the years from 1993 through 2007. At the end of each year, stocks are sorted into quintiles based on TIO measured at the end of the year. Within each of these TIO groups, stocks are then sorted into tercile portfolios based on PIN (Panel A) or $AdjPIN$ (Panel B) estimated over the year. Each panel reports the mean of PINs ($AdjPIN$s) , TIOs, and monthly returns.

Panel A: Portfolios Sorted Sequentially by TIO and PIN

TIO \ PIN	Lowest (A)	Medium (B)	Highest (C)	Difference (C)–(A)
		PIN		
Lowest (1)	0.171	0.309	0.512	0.341
2	0.156	0.245	0.421	0.265
3	0.134	0.198	0.326	0.192
4	0.123	0.175	0.265	0.142
Highest (5)	0.115	0.163	0.241	0.126
		Monthly Returns (%)		
Lowest (1)	0.912	1.651	1.735	0.823***
2	0.884	0.994	1.481	0.597**
3	0.991	1.116	1.145	0.154
4	1.156	1.275	1.278	0.122
Highest (5)	1.227	1.054	1.244	0.017
		TIO		
Lowest (1)	0.036	0.031	0.025	-0.011
2	0.208	0.198	0.198	-0.010
3	0.381	0.376	0.367	-0.014
4	0.547	0.545	0.521	-0.026
Highest (5)	0.716	0.713	0.683	-0.033

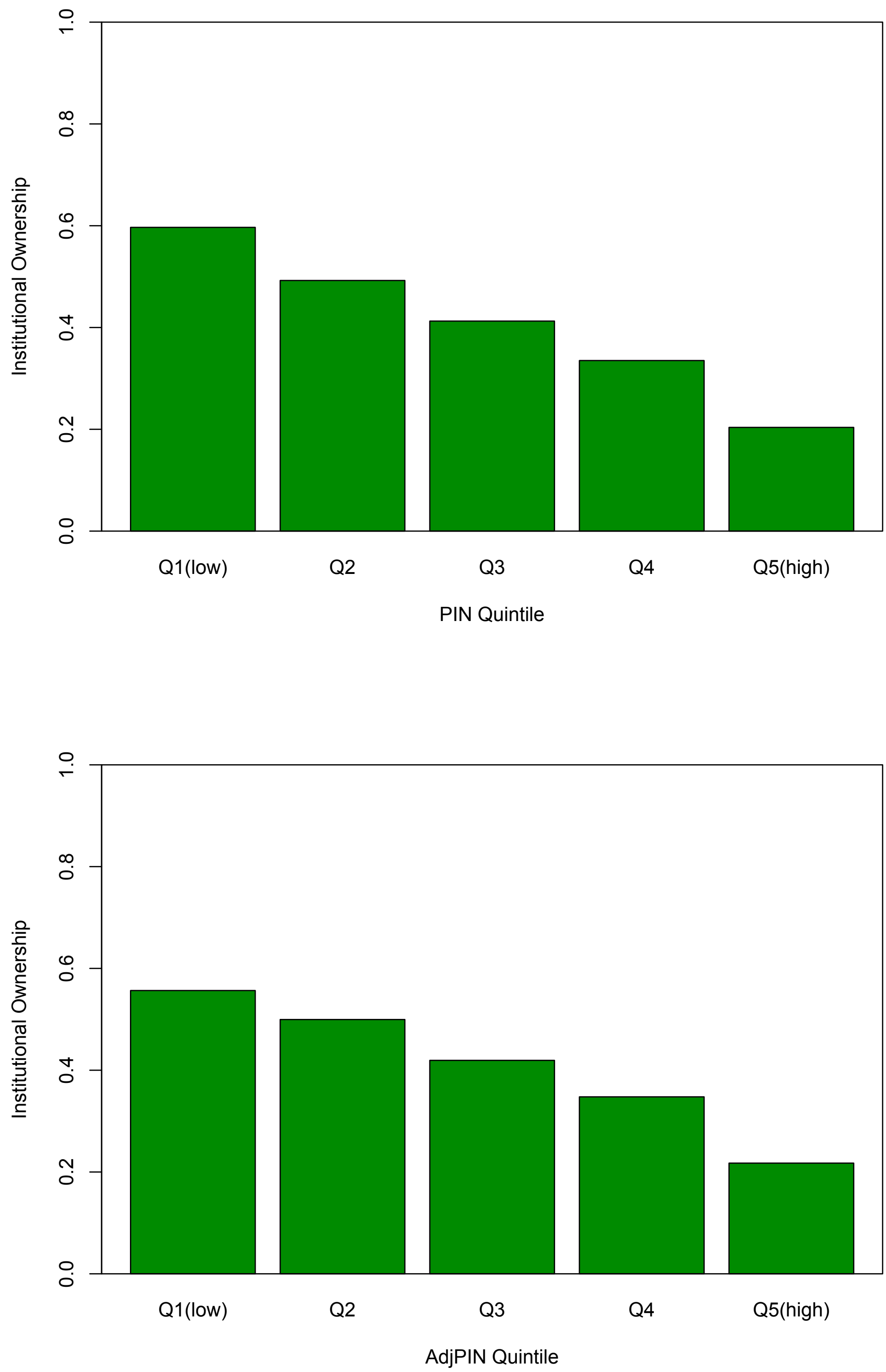
Panel B: Portfolios Sorted Sequentially by TIO and $AdjPIN$

TIO \ $AdjPIN$	Lowest (A)	Medium (B)	Highest (C)	Difference (C)–(A)
		$AdjPIN$		
Lowest (1)	0.131	0.239	0.378	0.247
2	0.123	0.208	0.334	0.211
3	0.115	0.176	0.271	0.156
4	0.102	0.154	0.226	0.124
Highest (5)	0.090	0.141	0.215	0.125
		Monthly Returns (%)		
Lowest (1)	1.016	1.460	1.715	0.699***
2	0.867	1.219	1.456	0.589**
3	0.984	1.125	1.145	0.161
4	1.211	1.181	1.305	0.094
Highest (5)	1.191	1.063	1.207	0.016
		TIO		
Lowest (1)	0.031	0.021	0.021	-0.010
2	0.280	0.192	0.186	-0.094
3	0.389	0.376	0.375	-0.014
4	0.541	0.545	0.527	-0.014
Highest (5)	0.706	0.697	0.676	-0.030

To visually examine the relation between TIO and information asymmetry, the average TIO is plotted against the PIN quintile (top panel) and the $AdjPIN$ quintile (bottom panel) in Figure 4.1. Figure 4.1 shows that the smallest-PIN quintile (Q1) has a greater TIO than Q2, and this relationship is monotonic across all PIN quintiles. A qualitatively similar result is reported for the $AdjPIN$ quintiles.

Figure 4.1: Institutional Ownership and Information Asymmetry

This figure plots the average TIO by PIN (top panel) and $AdjPIN$ (bottom panel) quintiles using yearly sample data for the 1993–2007 period.



4.4.2 Information Asymmetry and Institutional Ownership

To examine the relationship between institutional ownership and information asymmetry closely in a regression framework, equation (4.4) is estimated, the results of which are presented in Table 4.3. The dependent variables are PIN (Panel A) and $AdjPIN$ (Panel B).

The OLS regression results are presented in column 1 of Table 4.3. The coefficient estimate of TIO is negative and highly significant at the 1% level in both panels, suggesting that institutional ownership has a negative effect on a firm's information environment.

Table 4.3: Institutional Ownership and Information Asymmetry

This table reports the coefficient estimates from the following regression:

$$INFO_{i,t} = \beta_0 + \beta_1 TIO_{i,t-1} + \gamma_j CONTROl_{i,t-1} + e_{i,t}$$

The dependent variable is measured by either PIN or $AdjPIN$, both estimated in year t. The key independent variable is TIO, measured in year $t-1$. $CONTROL$ is a vector that contains the same control variables as discussed in Subsection 4.3.2 , all measured in year $t-1$. Panels A (B) report the regressions where the dependent variable is PIN ($AdjPIN$). Column 1 reports the pooled OLS results. Column 2 reports the Fama and MacBeth's (1973) regression results. Column 3 displays the firm fixed effects regression results. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Probability of Informed Trading (PIN)			
	OLS	FM	FE
	1	2	3
TIO	-0.042***	-0.060***	-0.026***
	(0.007)	(0.007)	(0.008)
$SIZE$	-0.029***	-0.027***	-0.028***
	(0.002)	(0.002)	(0.002)
MTB	-0.002***	-0.002***	0.001
	(0.001)	(0.001)	(0.001)
$TURN$	-0.096***	-0.106***	-0.067***
	(0.011)	(0.011)	(0.011)
$Ln(AGE)$	0.002	0.002***	-0.004
	(0.001)	(0.001)	(0.003)
LEV	-0.001	-0.005**	0.002
	(0.005)	(0.002)	(0.006)
$CASH$	0.012**	0.008	-0.001
	(0.006)	(0.005)	(0.009)
RD	-0.054***	-0.080***	-0.037
	(0.014)	(0.012)	(0.025)
ROA	0.013**	0.009	-0.001
	(0.007)	(0.009)	(0.010)
$VROA$	0.012	0.024**	-0.028*
	(0.012)	(0.010)	(0.015)
$DIVER$	0.002	0.013**	-0.008
	(0.003)	(0.006)	(0.005)
$DIVD$	0.000	-0.000	-0.001
	(0.002)	(0.001)	(0.003)
$SP500$	0.016***	0.017***	0.043
	(0.004)	(0.004)	(0.038)
$ALYST$	-0.004***	-0.004***	-0.009***
	(0.001)	(0.001)	(0.002)
$CLOSE$	0.026**	0.011	-0.006
	(0.013)	(0.016)	(0.015)
Firm FE	No	No	Yes
Industry FE	Yes	Yes	No
Year FE	Yes	No	Yes
Adj R^2	0.458		0.630
Obs.	19,362	19,362	19,362

Panel B: Adjusted Probability of Informed Trading (AdjPIN)			
	OLS	FM	FE
	1	2	3
TIO	-0.025***	-0.036***	-0.009**
	(0.003)	(0.003)	(0.004)
$SIZE$	-0.021***	-0.020***	-0.017***
	(0.001)	(0.002)	(0.001)
MTB	-0.002***	-0.002***	-0.000
	(0.001)	(0.001)	(0.001)
$TURN$	-0.058***	-0.062***	-0.025***
	(0.007)	(0.009)	(0.009)
$Ln(AGE)$	-0.000	0.000	-0.003
	(0.001)	(0.001)	(0.002)
LEV	-0.000	-0.003	0.006
	(0.004)	(0.002)	(0.005)
$CASH$	0.004	0.000	-0.008
	(0.004)	(0.006)	(0.008)
RD	-0.025***	-0.037**	-0.009
	(0.007)	(0.015)	(0.020)
ROA	0.009	0.009	0.000
	(0.006)	(0.010)	(0.008)
$VROA$	0.020**	0.030**	-0.003
	(0.009)	(0.011)	(0.013)
$DIVER$	0.001	0.011	-0.002
	(0.002)	(0.008)	(0.004)
$DIVD$	0.001	0.001	-0.000
	(0.002)	(0.001)	(0.002)
$SP500$	0.004	0.009***	0.032***
	(0.002)	(0.002)	(0.005)
$ALYST$	-0.003***	-0.002***	-0.005***
	(0.001)	(0.001)	(0.002)
$CLOSE$	0.014*	0.008	0.004
	(0.007)	(0.007)	(0.011)
Firm FE	No	No	Yes
Industry FE	Yes	Yes	No
Year FE	Yes	No	Yes
Adj R^2	0.422		0.526
Obs.	19,362	19,362	19,362

Although the results in column 1 show a negative effect of institutional ownership on information asymmetry, a major concern is the omitted variable problem. To partially address this issue, a firm fixed effects regression is used to control for unobserved time-invariant sources of firm heterogeneity, the results of which are reported in column 3. In addition, the two-pass Fama and MacBeth's (1973) regression is used to account for the possibility that residuals are correlated among firms in a given year, and the results are presented in column 2. Both columns 2–3 show that the coefficient estimates of TIO remain negative and highly significant at the 1% level. When the dependent variable is measured by $AdjPIN$ (Panel B), the results for TIO remain qualitatively similar. These results suggest that there is robust evidence of a negative effect of institutional ownership on information asymmetry as captured by PIN and $AdjPIN$ even after controlling for firm fixed effects and other confounding influences.

4.4.3 Information Asymmetry and Expected Returns

To investigate the pricing effect of information asymmetry, equation (4.5) was estimated based on three portfolios single-sorted on the basis of the PIN ($AdjPIN$) measure and a hedge portfolio that takes a long position in the largest-PIN (largest-$AdjPIN$) stocks and a short position in the smallest-PIN (smallest-$AdjPIN$) stocks. Table 4.4 shows the coefficient estimates with heteroskedasticity-robust standard errors in parentheses. Panel A presents the estimates for equally weighted PIN-sorted ($AdjPIN$-sorted) portfolios. Panel B displays the estimates for value weighted PIN-sorted ($AdjPIN$-sorted) portfolios.

Table 4.4: Information Asymmetry and Stock Returns

This table reports the estimates of the following Carhart's (1997) 4-factor model:

$$R_t^{\text{hedge}} = \alpha_{\text{INFO}} + \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 UMD_t + e_t.$$

The dependent variable are the monthly returns of three portfolios single-sorted by PIN ($AdjPIN$) and one hedge portfolio that takes a long position in the largest-PIN (largest-$AdjPIN$) stocks and a short position in the smallest-PIN (smallest-$AdjPIN$) stocks. The intercept α_{PIN} (α_{AdjPIN}) is the abnormal return, $MKTRF$, SMB, and HML are the three factors of Fama and French (1993), and UMD is the Carhart's (1997) momentum factor. Panel A shows the estimates for the equally weighted portfolios. Panel B displays the estimates for the value-weighted portfolios. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Equally Weighted Portfolios

	Portfolios single-sorted by PIN ($AdjPIN$)			
	Smallest	Medium	Largest	Hedge Portfolio
	(A)	(B)	(C)	(C)–(A)
α_{PIN}	0.003***	0.006***	0.010***	0.007***
	(0.001)	(0.002)	(0.002)	(0.002)
$MKTRF$	0.967***	0.746***	0.395***	-0.572***
	(0.030)	(0.071)	(0.057)	(0.062)
SMB	0.196***	0.422***	0.363***	0.168***
	(0.038)	(0.061)	(0.053)	(0.054)
HML	0.636***	0.478***	0.289***	-0.347***
	(0.040)	(0.069)	(0.064)	(0.073)
UMD	-0.149***	-0.115***	-0.113***	0.036
	(0.023)	(0.026)	(0.032)	(0.045)
R^2	0.919	0.816	0.653	0.632
Obs.	180	180	180	180
α_{AdjPIN}	0.004***	0.003**	0.008***	0.004**
	(0.001)	(0.002)	(0.002)	(0.002)
$MKTRF$	1.019***	1.000***	0.770***	-0.249***
	(0.031)	(0.047)	(0.058)	(0.054)
SMB	0.258***	0.649***	0.693***	0.435***
	(0.041)	(0.057)	(0.064)	(0.055)
HML	0.565***	0.649***	0.494***	-0.070
	(0.042)	(0.052)	(0.073)	(0.081)
UMD	-0.185***	-0.221***	-0.199***	-0.014
	(0.021)	(0.056)	(0.062)	(0.055)
R^2	0.937	0.912	0.817	0.487
Obs.	180	180	180	180

Panel B: Value-Weighted Portfolios				
	Portfolios single-sorted by PIN ($AdjPIN$)			
	Smallest	Medium	Largest	Hedge Portfolio
	(A)	(B)	(C)	(C)–(A)
α_{PIN}	0.004***	0.004***	0.008***	0.004**
	(0.001)	(0.001)	(0.002)	(0.002)
$MKTRF$	1.026***	1.010***	0.785***	-0.240***
	(0.031)	(0.043)	(0.055)	(0.057)
SMB	0.194***	0.601***	0.688***	0.493***
	(0.039)	(0.055)	(0.059)	(0.058)
HML	0.620***	0.626***	0.487***	-0.133
	(0.043)	(0.049)	(0.070)	(0.084)
UMD	-0.172***	-0.177***	-0.166**	0.006
	(0.020)	(0.039)	(0.068)	(0.073)
R^2	0.932	0.917	0.838	0.555
Obs.	180	180	180	180
α_{AdjPIN}	0.004***	0.003**	0.007***	0.003**
	(0.001)	(0.001)	(0.002)	(0.002)
$MKTRF$	1.024***	1.008***	0.789***	-0.236***
	(0.030)	(0.044)	(0.052)	(0.050)
SMB	0.209***	0.608***	0.660***	0.451***
	(0.038)	(0.054)	(0.059)	(0.052)
HML	0.569***	0.665***	0.512***	-0.056
	(0.041)	(0.049)	(0.064)	(0.074)
UMD	-0.163***	-0.190***	-0.162***	0.001
	(0.018)	(0.045)	(0.053)	(0.053)
R^2	0.939	0.914	0.847	0.545
Obs.	180	180	180	180

As shown in both panels in Table 4.4, the estimated abnormal return of each portfolio (α_{PIN} and α_{AdjPIN}) is positive and increases monotonically from the smallest-PIN (smallest-$AdjPIN$) to the largest-PIN (largest-$AdjPIN$) portfolios. More importantly, the abnormal return of the hedge portfolios is positive and statistically significant. The coefficient estimate of 0.007 on α_{PIN} in Panel A, for example, suggests that a trading strategy that longs the stocks in the largest-PIN tercile and shorts the stocks in the lowest-PIN tercile earns an abnormal return of 0.7% for the equally weighted portfolios. Compared with the PIN-hedge portfolio, the abnormal return on the $AdjPIN$-hedge portfolio is lower in both panels. These results show that abnormal returns are earned on stocks with greater information asymmetry in excess of the standard risk factors, implying that investors appear to require compensation for information risk that arises from information asymmetry, which is consistent with much of the earlier work that uses PIN as a measure of information asymmetry.

4.4.4 Information Asymmetry, Stock Returns, and Institutional Ownership – The Portfolio Approach

A main purpose of this study is to identify a circumstance under which information asymmetry is likely to exhibit the greatest effect on expected returns, coupled with a circumstance under which information asymmetry is most likely to be in evidence. Given the baseline results presented in Section 4.4.2 that institutional ownership has a negative effect on information asymmetry, together with the evidence reported in Section 4.4.3 that information asymmetry is significantly positively related to expected returns, a natural question to ask is whether the pricing effect of information asymmetry is affected by institutional ownership as predicted in Hypothesis 4.1.

To answer this question, equation (4.5) is re-estimated but based on five hedge portfolios double-sorted by TIO and PIN ($AdjPIN$) to account for different levels of institutional ownership. Table 4.5 presents the results for the regression model (4.5). Panel A reports the regressions for the equally weighted portfolios. Panel B displays the regressions for the value-weighted portfolios.

Table 4.5: Information Asymmetry, Institutional Ownership, and Stock Returns – The 4-Factor Model

This table reports the coefficient estimates from the following Carhart's (1997) 4-factor regression:

$$R_t^{\text{hedge}} = \alpha_{\text{INFO}} + \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 UMD_t + e_t.$$

The dependent variable is the monthly return of the hedge portfolio formed by taking a long position in the largest-PIN (largest-$AdjPIN$) stocks and a short position in the smallest-PIN (smallest-$AdjPIN$) stocks. The intercept α_{INFO} refers to either α_{PIN} or α_{AdjPIN}—the abnormal return of the hedge portfolio. $MKTRF$, SMB, and HML are the three factors of Fama and French (1993) and UMD is the Carhart's (1997) momentum factor. Panel A (B) shows the results for the equally weighted (value-weighted) portfolios. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Equally Weighted Portfolios

	Hedge portfolios sorted by TIO				
	Lowest (1)	2	3	4	Highest (1)
α_{PIN}	0.008***	0.006***	-0.000	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.310***	-0.191**	-0.045	-0.058	-0.020
	(0.084)	(0.077)	(0.047)	(0.047)	(0.035)
SMB	-0.171*	0.126*	0.537***	0.513***	0.426***
	(0.102)	(0.072)	(0.055)	(0.064)	(0.042)
HML	0.164	0.101	0.072	0.162***	0.047
	(0.111)	(0.103)	(0.084)	(0.062)	(0.041)
UMD	0.102**	0.093*	0.044	0.004	0.099***
	(0.048)	(0.056)	(0.038)	(0.051)	(0.035)
R^2	0.313	0.206	0.559	0.537	0.621
Obs.	180	180	180	180	180
α_{AdjPIN}	0.006**	0.005**	-0.000	-0.000	-0.000
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.147**	-0.135*	-0.039	-0.064	-0.087**
	(0.071)	(0.070)	(0.048)	(0.047)	(0.040)
SMB	-0.085	0.086	0.525***	0.580***	0.444***
	(0.070)	(0.070)	(0.054)	(0.054)	(0.053)
HML	0.192**	0.105	0.138*	0.203***	0.137**
	(0.088)	(0.089)	(0.073)	(0.055)	(0.053)
UMD	-0.027	0.056	0.073**	0.005	0.062*
	(0.054)	(0.049)	(0.031)	(0.047)	(0.034)
R^2	0.181	0.119	0.559	0.614	0.597
Obs.	180	180	180	180	180

Panel B: Value-Weighted Portfolios

	Hedge portfolios sorted by TIO				
	Lowest (1)	2	3	4	Highest (1)
α_{PIN}	0.008***	0.006***	-0.000	-0.000	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.299***	-0.180**	-0.024	-0.049	-0.008
	(0.073)	(0.074)	(0.044)	(0.044)	(0.035)
SMB	-0.159*	0.154**	0.566***	0.512***	0.421***
	(0.095)	(0.070)	(0.054)	(0.062)	(0.041)
HML	0.113	0.068	0.095	0.160***	0.041
	(0.097)	(0.102)	(0.080)	(0.059)	(0.040)
UMD	0.072*	0.081*	0.045	0.007	0.101***
	(0.044)	(0.048)	(0.036)	(0.046)	(0.033)
R^2	0.314	0.192	0.604	0.558	0.628
Obs.	180	180	180	180	180
α_{AdjPIN}	0.005**	0.005***	-0.001	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
$MKTRF$	-0.147**	-0.126**	-0.043	-0.065	-0.079**
	(0.064)	(0.063)	(0.044)	(0.045)	(0.035)
SMB	-0.124	0.129**	0.539***	0.562***	0.414***
	(0.080)	(0.061)	(0.052)	(0.058)	(0.052)
HML	0.124	0.044	0.153**	0.213***	0.138***
	(0.081)	(0.080)	(0.067)	(0.053)	(0.046)
UMD	0.018	0.068**	0.059**	0.008	0.061**
	(0.062)	(0.034)	(0.029)	(0.042)	(0.030)
R^2	0.220	0.141	0.602	0.613	0.591
Obs.	180	180	180	180	180

Several remarks are in order. First, the abnormal returns of the hedge portfolios decrease in TIO. Second, the abnormal returns of both the PIN and $AdjPIN$ hedge portfolios (α_{PIN} and α_{AdjPIN}) are positive and significant for the lowest- and the second lowest-TIO groups (columns 1–2) only, ranging between 0.5% and 0.8% per month. For the remaining TIO-sorted portfolios, these coefficient estimates are insignificant with economic effect being much smaller (one of them is close to zero). These results suggest that the pricing effect of information asymmetry is restricted to low-TIO stocks only, implying that a substitution effect may operate between institutional ownership and information asymmetry. For instance, uninformed investors, such as retail traders, require a higher expected return on stocks that contain substantial asymmetric information as compensation for information risk that arise from their informational disadvantages; however, this adverse effect of information asymmetry is likely to be mitigated in stocks with high institutional ownership levels.

Consolidating Table 4.4 and Table 4.5 suggests that the results documented for the aggregate-TIO hedge portfolios are driven largely by a subset of stocks, i.e., stocks with low institutional ownership levels. Although the last column in Table 4.4 shows that the hedge portfolio yields a positive and significant abnormal return, it appears, as shown in Table 4.5, that this result is actually driven by stocks with low institutional ownership. High-TIO stocks do not contribute to abnormal returns in any meaningful sense. Hence, these results support Hypothesis 4.1 that the pricing effect of information asymmetry is significant only for stocks with low levels of institutional ownership.

Pastor and Stambaugh (2003) study whether market-wide liquidity is a state variable that is important for asset pricing, and find that a liquidity risk factor is priced in the cross section of stock returns. Thus, equation (4.5) is augmented with the liquidity factor of Pastor and Stambaugh (2003) to see whether the main results still hold. Table 4.6 shows the results of this augmented regression. Again, the results remain qualitatively similar.

Table 4.6: Information Asymmetry, Institutional Ownership, and Stock Returns – The 5-Factor Model

This table reports the coefficient estimates from the following 5-factor model:

$$\begin{aligned} R_t^{\text{hedge}} &= \alpha_{\text{INFO}} + \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t \\ &\quad + \beta_4 UMD_t + \beta_5 PSLIQ_{i,t} + e_t. \end{aligned}$$

The dependent variable is the monthly return of the hedge portfolio formed by taking a long position in the largest-PIN (largest-$AdjPIN$) stocks and a short position in the smallest-PIN (smallest-$AdjPIN$) stocks. The intercept α_{INFO} refers to either α_{PIN} or α_{AdjPIN}. $MKTRF$, SMB, and HML are the three factors of Fama and French (1993), UMD is the Carhart's (1997) momentum factor, and $PSLIQ$ is the Pastor and Stambaugh's (2003) liquidity factor. Panel A (B) shows the results for the equally weighted (value-weighted) portfolios. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Equally Weighted Portfolios

	Hedge portfolios sorted by TIO				
	Lowest (1)	2	3	4	Highest (1)
α_{PIN}	0.008***	0.006***	-0.000	-0.000	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.323***	-0.165**	-0.034	-0.040	-0.012
	(0.088)	(0.081)	(0.046)	(0.050)	(0.037)
SMB	-0.177*	0.139*	0.542***	0.522***	0.430***
	(0.101)	(0.073)	(0.056)	(0.063)	(0.042)
HML	0.149	0.130	0.084	0.183***	0.056
	(0.112)	(0.108)	(0.088)	(0.065)	(0.044)
UMD	0.105**	0.089*	0.042	0.001	0.097***
	(0.048)	(0.053)	(0.038)	(0.053)	(0.035)
$PSLIQ$	0.047	-0.098	-0.039	-0.068*	-0.031
	(0.086)	(0.060)	(0.049)	(0.040)	(0.031)
R^2	0.315	0.221	0.561	0.545	0.623
Obs.	180	180	180	180	180
α_{AdjPIN}	0.006**	0.005**	-0.000	-0.000	0.000
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.143*	-0.129*	-0.037	-0.046	-0.066
	(0.076)	(0.073)	(0.048)	(0.049)	(0.041)
SMB	-0.083	0.089	0.526***	0.589***	0.454***
	(0.070)	(0.069)	(0.055)	(0.053)	(0.052)
HML	0.197**	0.111	0.140*	0.223***	0.161***
	(0.093)	(0.092)	(0.079)	(0.058)	(0.057)
UMD	-0.028	0.055	0.072**	0.002	0.059*
	(0.054)	(0.048)	(0.031)	(0.048)	(0.035)
$PSLIQ$	-0.018	-0.022	-0.009	-0.068*	-0.079***
	(0.064)	(0.062)	(0.045)	(0.035)	(0.029)
R^2	0.182	0.120	0.559	0.621	0.611
Obs.	180	180	180	180	180

Panel B: Value-Weighted Portfolios

	Hedge portfolios sorted by TIO				
	Lowest (1)	2	3	4	Highest (5)
α_{PIN}	0.008***	0.006***	0.000	0.000	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.307***	-0.158**	-0.013	-0.031	-0.002
	(0.077)	(0.077)	(0.044)	(0.047)	(0.037)
SMB	-0.163*	0.165**	0.571***	0.521***	0.424***
	(0.094)	(0.071)	(0.054)	(0.062)	(0.041)
HML	0.104	0.093	0.107	0.181***	0.048
	(0.098)	(0.107)	(0.084)	(0.062)	(0.042)
UMD	0.074*	0.078*	0.043	0.004	0.100***
	(0.043)	(0.046)	(0.037)	(0.047)	(0.034)
$PSLIQ$	0.030	-0.084	-0.040	-0.069*	-0.024
	(0.074)	(0.058)	(0.048)	(0.039)	(0.031)
R^2	0.315	0.203	0.607	0.567	0.629
Obs.	180	180	180	180	180
α_{AdjPIN}	0.005**	0.005***	-0.001	-0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
$MKTRF$	-0.145**	-0.116*	-0.039	-0.044	-0.058
	(0.068)	(0.065)	(0.044)	(0.047)	(0.035)
SMB	-0.123	0.133**	0.541***	0.573***	0.425***
	(0.079)	(0.061)	(0.053)	(0.056)	(0.050)
HML	0.126	0.055	0.157**	0.237***	0.161***
	(0.087)	(0.082)	(0.073)	(0.056)	(0.049)
UMD	0.018	0.066*	0.058*	0.004	0.057*
	(0.062)	(0.034)	(0.030)	(0.044)	(0.030)
$PSLIQ$	-0.008	-0.035	-0.016	-0.080**	-0.076***
	(0.051)	(0.054)	(0.042)	(0.034)	(0.028)
R^2	0.220	0.144	0.602	0.624	0.606
Obs.	180	180	180	180	180

As a robustness check, this study also uses an alternative sorting procedure with the portfolio approach in which stocks are sorted into terciles, rather than quintiles, based on TIO. Then within each TIO tercile, stocks are sorted into three groups based on the PIN ($AdjPIN$) measure. A total of nine portfolios are formed by this procedure. A reverse sorting, i.e., stocks sorted first by PIN ($AdjPIN$) and then by TIO, is also used. None of these procedures qualitatively alters the main results, though. For brevity, these results are not reported in this study.

Overall, this subsection provides consistent evidence in support of Hypothesis 4.1 that the pricing effect of information asymmetry is significant only for stocks with low levels of institutional ownership. There is no such evidence for stocks with high institutional ownership levels. These results suggest that investors only require compensation for information risk from stocks with low institutional ownership levels.

4.4.5 Information Asymmetry, Stock Returns, and Institutional Ownership – The Fama-MacBeth Regressions

Aside from the portfolio approach, this study also uses a regression framework. Specifically, stocks are first sorted into terciles based on TIO measured at the end of the year, and three dummy variables are used to index the group to which a stock belongs. These dummy variables are then interacted with either PIN or $AdjPIN$, which is denoted by $INFO$, in a cross-section regression as specified in equations (4.6) and (4.7). These models are then estimated using the Fama and MacBeth's (1973) regression method.

The advantage of this regression framework is that some variables such as size or book-to-market that may be correlated with institutional ownership are simultaneously controlled for. If the results are consistent with those of the portfolio approach presented earlier, then the coefficient estimate of the interaction term ($INFO \times DL$) should be positive and significant, whereas the coefficient on ($INFO \times DH$) should be statistically insignificant, regardless of the use of information asymmetry proxies.

Table 4.7 presents the regressions estimating equations (4.6) and (4.7). Columns 1 and 3 show results that are consistent with earlier work regarding the controversy over the pricing effect of information asymmetry as captured by PIN and $AdjPIN$. While PIN is priced as indicated by a positive and significant coefficient estimate of $INFO$ in column 1, $AdjPIN$ is not priced because the coefficient estimate of $INFO$ shown in column 3 is insignificant.

It should be noted, however, that the main interest in this regression framework is in the coefficient estimates of the interaction terms. Column 2 shows that the coefficient estimate of $(PIN \times DL)$ is positive and statistically significant, while the coefficient on $(PIN \times DH)$ is insignificant. Column 4 shows broadly similar results for $AdjPIN$. Again, these results suggest that the pricing effect of information asymmetry captured by PIN and $AdjPIN$ exists only among stocks with low institutional ownership levels.

Overall, this subsection provides results that are consistent with the portfolio approach reported earlier and reinforces the argument that only stocks with low levels of institutional ownership exhibit a pricing effect of information asymmetry. This evidence thus provides support for Hypothesis 4.1.

Table 4.7: Information Asymmetry, Institutional Ownership, and Stock Returns – The Fama-MacBeth Regressions

This table reports the coefficient estimates from the following Fama and MacBeth's (1973) regressions:

$$\begin{aligned} R_{i,t} &= \beta_0 + \beta_1 INFO_{i,t-1} + \beta_2 BETA_{i,t-1} + \beta_3 SIZE_{i,t-1} \\ &\quad + \beta_4 BTM_{i,t-1} + e_{i,t}, \end{aligned}$$

$$\begin{aligned} R_{i,t} &= \beta_0 + \beta_1 (INFO_{i,t-1} \times DL) + \beta_2 (INFO_{i,t-1} \times DM) \\ &\quad + \beta_3 (INFO_{i,t-1} \times DH) + \beta_4 DM + \beta_5 DH + \beta_6 BETA_{i,t-1} \\ &\quad + \beta_7 SIZE_{i,t-1} + \beta_8 BTM_{i,t-1} + e_{i,t}. \end{aligned}$$

The dependent variable is the monthly return of stock i. $INFO$ is either PIN or $AdjPIN$. $BETA$ is the beta of the stock estimated based on a sample of the past 60 months. Three dummy variables— DL, DM, and DH— index whether the stock belongs to the low-, medium- or high-TIO group, respectively. Columns 1 and 3 display the results of the first regression model. Columns 3 and 4 display the results of the second regression model. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	PIN	PIN	$AdjPIN$	$AdjPIN$
	1	2	3	4
$INFO$	0.015***		0.008	
	(0.003)		(0.008)	
$(INFO \times DL)$		0.018***		0.012**
		(0.003)		(0.006)
$(INFO \times DM)$		0.014**		0.004*
		(0.006)		(0.002)
$(INFO \times DH)$		0.010		0.023
		(0.009)		(0.015)
DM		0.007***		0.009***
		(0.001)		(0.001)
DH		0.006***		0.009***
		(0.002)		(0.002)
$SIZE$	0.002***	0.001***	0.002***	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
$BETA$	-0.000	-0.001	-0.000	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
BTM	-0.005***	-0.006***	-0.005***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Intercept	-0.007**	-0.006*	-0.003	-0.002
	-0.003	-0.003	-0.003	-0.003

4.5 Conclusions

This study examines the pricing effect of information risk that originates from information asymmetry and is captured by two widely used proxies—the probability of information-based trading (PIN) of Easley, Hvidkjaer, and O'Hara (2002) and the "adjusted" probability of information-based trading ($AdjPIN$) of Duarte and Young (2009). The portfolio approach which does not distinguish stocks by institutional ownership shows that both PIN and $AdjPIN$ exhibit a pricing effect beyond the standard risk factors. In a regression framework where stock returns are regressed on PIN ($AdjPIN$) in a sample of all individual stocks, only the PIN measure is priced in the cross section of stock returns. When institutional ownership is considered, however, this controversial result disappears. A pricing effect of information asymmetry is observed only for stocks with low levels of institutional ownership, and there is no such evidence for stocks with high levels of institutional ownership.

A natural question to be asked is why there is no pricing effect of PIN and $AdjPIN$ for stocks with high institutional ownership levels. Two possibilities emerge. First, empirical research has long established that institutional investors can act as active monitors by directly intervening in firms' activities (Ferreira and Matos, 2008; Gillan and Starks, 2000; Shleifer and Vishny, 1986). This monitoring role can potentially mitigate information asymmetry in a stock. More importantly, institutional monitoring can prevent the leakage and spread of harmful private information, so that uninformed investors treat institutional ownership in a firm as a credible signal that the information risk that originates from information asymmetry is mitigated.

Second, as a measure of information asymmetry, neither PIN nor $AdjPIN$ distinguishes among the types of private information in the trading of a stock. In a sense, while both PIN and $AdjPIN$ measure the quantity of private signals, they do not take into account the effectiveness of such signals that reveal the fundamental value of a firm. Therefore, it is possible that uninformed investors regard institutional ownership as an alternative signal for assessing information risk. These considerations imply that the pricing effect of information asymmetry as captured by PIN and $AdjPIN$ obtains only for those firms that have low levels of institutional ownership.

Overall, this study contributes to the literature by providing new evidence on how institutional investors can alter the relation between information asymmetry and expected returns. This study suggests that the question at issue is not as much about whether PIN and $AdjPIN$ adequately capture information asymmetry, but more about under which circumstances information asymmetry does matter to asset pricing. Uninformed investors do not require compensation for information risk from stocks with high levels of institutional ownership.

Chapter 5

Conclusions

This thesis presents three independent studies that relate to institutional investors, corporate innovation, and information. The common theme in these studies is the roles of institutional investors in the financial markets. The thesis seeks to answer the following important questions. First, do foreign institutional investors enhance or impede corporate innovation in domestic firms in non-U.S. economies around the world? Second, does institutional investors' heterogeneity affect information asymmetry between informed and uninformed investors in the U.S. equity markets? Third, what is the role of institutional investors in explaining the empirical controversy over the pricing effect of information asymmetry in the U.S. equity markets?

The first study examines the role of foreign institutional investors in promoting corporate innovation in a sample of domestic firms in 26 non-U.S. economies over the 2000–2010 period, using a unique dataset of firm-level global patents and citations. Two competing hypotheses as to how foreign institutions affect innovation are proposed: (i) Foreign institutional investors impede firm innovation, and (ii) Foreign institutional investors enhance innovation. The results show that there is a positive effect of foreign institutional ownership on innovation, which supports the second hypothesis. To establish causality, this study uses an instrumental variable approach, as well as a difference-in-differences approach that relies on the plausibly exogenous variation in foreign institutional ownership that is created by a quasi-natural experiment, and finds that this positive effect is causal.

After establishing causality, this study explores three channels through which foreign institutions spur innovation. First, foreign institutions might act as active monitors to mitigate managerial myopia and slack associated with firms' risky innovative activity. Second, they might provide insurance for firm managers with career or reputation concerns against innovation failures. Third, they might promote technology transfers from high-innovation countries. The results show that only independent and long-term foreign institutions promote firm innovation, while grey and short-term foreign institutions do not, suggesting that foreign institutional investors enhance innovation through their active monitoring of the firms. Moreover, the sensitivities of CEO turnover and compensation to firm performance are lower in firms with greater foreign institutional ownership, which suggests that foreign institutional investors provide insurance for firm managers with career or reputation concerns against possible innovation failures. Finally, the results show that only foreign institutions from high-innovation countries promote firm innovation, which is consistent with the conjecture that foreign institutional investors facilitate knowledge and technology transfers from high-innovation economies.

The second study examines how the heterogeneity of institutional investors affects information asymmetry between informed and uninformed investors in the U.S. equity markets. It shows that while information asymmetry is significantly positively associated with short-term institutional ownership, it is negatively related to total institutional ownership, top-five largest institutional ownership, institutional ownership concentration, independent institutional ownership, and long-term institutional ownership. These results suggest that investment horizon, and type and concentration of institutional ownership have significant effects on a firm's information environment. This study also finds evidence of a negative relationship between information asymmetry and the number of institutional investors, suggesting that the number of institutional investors in a firm can potentially mitigate information asymmetry.

The third study examines how institutional ownership contributes to the recent debate on the empirical controversy over the pricing effect of information risk that arises from information asymmetry between informed and uninformed traders in the U.S. stock markets. This study argues that the pricing effect of information risk captured by the PIN measure of Easley, Hvidkjaer, and O'Hara (2002) and the $AdjPIN$ measure of Duarte and Young (2009) should be clearer in a circumstance in which information asymmetry is most likely to be in evidence. This study thus conjectures that institutional investors should affect the relation between information risk and expected returns because of their information and monitoring roles. The results show that information asymmetry as captured by PIN and $AdjPIN$ is priced only for stocks with low levels of institutional ownership. This pricing effect is non-existent for stocks with high institutional ownership levels. These results suggest that the question at issue is not as much about whether PIN and $AdjPIN$ adequately capture information asymmetry, but more about under which circumstances information asymmetry matters to asset pricing. The evidence suggests that investors only require compensation for information risk from stocks with low institutional ownership levels only.

Although this thesis provides a comprehensive analysis of the aforementioned issues, there are possible extensions for further research. Future studies can examine how the positive effect of foreign institutional ownership on firm innovation translates into shareholder value creation, such as long-term firm value and profitability or countries' long-run economic growth and comparative advantages. In addition, future studies can investigate whether institutional ownership plays a role in explaining the empirical controversy over the pricing of information asymmetry in an international setting rather than just the U.S. markets as in this thesis.

Appendices

1 Thomson Reuter's DWPI Classification System

Table 1: Thomson Reuters's DWPI Classification System

DWPI categorizes patents using a simple classification system for all technologies. Patents are divided into three broad areas: Chemical, Engineering, and Electronic and Electrical Engineering. Each of these is then further classified into smaller subject areas called "Sections", which describe the technical area or areas covered by the patent. There are a total of 20 such sections, designated A–M for Chemical, P–Q for Engineering, and S–X for Electronic and Electrical Engineering.

Chemical	Engineering	Electronic and Electrical Engineering
A. Polymers and Plastics	P1. Agriculture, Food, Tobacco	S. Instrumentation, Measuring and Testing
B. Pharmaceuticals	P2. Personal, Domestic	T. Computing and Control
C. Agricultural Chemicals	P3. Health, Amusement	U. Semiconductors and Electronic Circuitry
D. Food, Detergents, Water Treatment and Biotechnology	P4. Separating, Mixing	V. Electronic Components
E. General Chemicals	P5. Shaping Metal	W. Communications
F. Textiles and Paper-Making	P6. Shaping Non-metal	X. Electric Power Engineering
G. Printing, Coating, Photographic	P7. Pressing, Printing	
H. Petroleum	P8. Optics, Photography, General	
J. Chemical Engineering	Q1. Vehicles in General	
K. Nucleonics, Explosives and Protection	Q2. Special Vehicles	
L. Refractories, Ceramics, Cement and Electro(in)organics	Q3. Conveying, Packaging, Storing	
M. Metallurgy	Q4. Buildings, Construction	
	Q5. Engines, Pumps	
	Q6. Engineering Elements	
	Q7. Lighting, Heating	

2 Variable Definitions

Table 2: Variable Definitions

Variables	Definition and Source of Data
1. Innovation Variables	(Data Source: Thomson Innovation)
$Ln(1 + Patent)$	Natural logarithm of one plus the total number of patents granted to each firm in each year, scaled by the mean number of patent applications filed in a year for technology groups to which the patent belongs.
$Ln(1 + Citation)$	Natural logarithm of one plus the total number of citations made to each firm's patents in each year, scaled by the mean citation count received by each patent in a year for technology groups to which the patent belongs.
2. Institutional Ownership Variables	(Data Source: FactSet Ownership)
DIO	Domestic institutional ownership, defined as the sum of shares owned by all institutions domiciled in the same country as where the stock is listed as a percentage of the firm's total shares outstanding, set to zero if the stock is not held by any institution.
FIO	Foreign institutional ownership, defined as the sum of shares owned by all institutions domiciled in a country different from where the stock is listed as a percentage of the firm's total shares outstanding, set to zero if the stock is not held by any institution.
$FIO_{Independent}$	Independent foreign institutional ownership, defined as the sum of shares owned by all active foreign institutions (mutual funds and independent investment advisers) as a percentage of the firm's total shares outstanding.
FIO_{Grey}	Grey foreign institutional ownership, defined as the sum of shares owned by all passive foreign institutions (bank trusts, insurance companies, and other institutions) as a percentage of the firm's total shares outstanding.
$FIO_{Long-term}$	Long-term foreign institutional ownership, defined as the sum of shares owned by all foreign institutions that hold the stock for more than one year as a percentage of the firm's total shares outstanding.
$FIO_{Short-term}$	Short-term foreign institutional ownership, defined as the sum of shares owned by all foreign institutions that hold the stock for less than one year as a percentage of the firm's total shares outstanding.
$FIO_{HighInno}$	High-innovation foreign institutional ownership, defined as the sum of shares owned by all foreign institutions that come from high-innovation countries as a percentage of the firm's total shares outstanding.
$FIO_{LowInno}$	Low-innovation foreign institutional ownership, defined as the sum of shares owned by all foreign institutions that come from low-innovation countries as a percentage of the firm's total shares outstanding.

3. Control Variables	(Data Source: Worldscope)
TA	Book value of total assets measured at the end of the fiscal year in millions.
RD	Research and development expenditure scaled by total assets, measured at the end of the fiscal year, set to 0 if missing.
$Ln(SALE)$	Natural logarithm of net sales.
$Ln(AGE)$	Natural logarithm of the number of years since the firm has its listed price.
$CAEX$	Capital expenditure divided by total assets, measured at the end of the fiscal year.
PPE	Net properties, plants and equipment scaled by total assets, measured at the end of the fiscal year.
LEV	Ratio of total debt to total assets, measured at the end of the fiscal year.
ROA	Return on assets, defined as operating income before depreciation divided by total assets, measured at the end of the fiscal year.
KZ	The KZ index measured at the end of fiscal year, calculated as $-1.002 \times$ Cash flow [(Income before extraordinary items + Depreciation and Amortization)/Lagged net property, plant and equipment] + $0.283 \times Q$ [Market value of equity + book value of total assets − book value of equity − balance sheet deferred tax] + $3.139 \times$ Leverage[Total debt/Total assets] − $39.368 \times$ Dividends [(Preferred dividends + Common dividends)/Lagged net property, plant and equipment] − $3.315 \times$ Cash holdings [(Cash and short-term investment)/(Lagged net property, plant and equipment)].
Q	Growth opportunities, defined as market value of equity + book value of total assets − book value of equity − balance sheet deferred tax, scaled by total assets, measured at the end of the fiscal year.
HHI	Herfindahl-Hirschman Index of 4-digit standard industrial classification (SIC) industry to which the firm belongs, measured at the end of the fiscal year.
$HHISQ$	Squared HHI.
4. Country-level Innovation Variables	(Data Source: World Bank)
$Patent/GDP$	Total number of patent applications applied by all residents in a year of a country scaled by GDP.
$Patent/Pop$	Total number of patent applications applied by all residents in a year of a country scaled by total population.
$Patent/Firms$	Total number of patent applications applied by all residents in a year of a country scaled by the number of listed firms.
$Patent/Mcap$	Total number of patent applications applied by all residents in a year of a country scaled by market capitalization.

3 The Log-Likelihood Function of PIN

Following Easley, Hvidkjaer, and O'Hara (2010), the common term

$$e^{-\varepsilon_b-\varepsilon_s}\frac{(u+\varepsilon_s)^B(u+\varepsilon_s)^S}{B!S!}$$

in equation (3.1) is factored out because the computation of the factorial and exponential of a large number of buy and sell orders is likely to cause numerical overflow problems.

The log-likelihood function is specified as follows:

$$\begin{aligned} L\left(\vartheta|(B_t,S_t)_{t=1}^T\right) &= \sum_{t=1}^T[(-\varepsilon_b-\varepsilon_s)+B_t\ln(u+\varepsilon_b)+S_t\ln(u+\varepsilon_s)] \\ &\quad+\sum_{t=1}^T\ln[(1-a)x^{B_t}y^{S_t}+ade^{-u}y^{S_t}+a(1-d)e^{-u}x^{B_t}] \\ &\quad-\sum_{t=1}^T\ln(B_t!S_t!), \end{aligned}$$

where

$$x=\frac{\varepsilon_b}{(u+\varepsilon_b)}\in[0,1] \text{ and } y=\frac{\varepsilon_s}{u+\varepsilon_s}\in[0,1].$$

4 The Likelihood Function of $AdjPIN$

Duarte and Young (2009) extend the PIN model of Easley et al. (1996) to allow for the pervasive positive correlations between buyer- and seller-initiated order flow as actually observed in the data. They decompose PIN into two components: the asymmetric information component of PIN, which they term $AdjPIN$ ("adjusted" PIN), and the illiquidity component of PIN. Thus, $AdjPIN$ is PIN purged of all illiquidity effects unrelated to asymmetric information, and hence, according to Duarte and Young (2009), is a more accurate proxy for information asymmetry.

The likelihood function of the $AdjPIN$ model is specified as follows:

$$
\begin{aligned}
L(\vartheta|B,S) \;=\;& (1-a)(1-\theta)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \\
&+(1-a)\theta e^{-(\varepsilon_b+\Delta_b)}\frac{(\varepsilon_b+\Delta_b)^B}{B!}e^{-(\varepsilon_s+\Delta_s)}\frac{(\varepsilon_s+\Delta_s)^S}{S!} \\
&+a(1-\theta')(1-d)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-(u_s+\varepsilon_s)}\frac{(u_s+\varepsilon_s)^S}{S!} \\
&+a\theta'(1-d)e^{-(\varepsilon_b+\Delta_b)}\frac{(\varepsilon_b+\Delta_b)^B}{B!}e^{-(u_s+\varepsilon_s+\Delta_s)}\frac{(u_s+\varepsilon_s+\Delta_s)^S}{S!} \\
&+a(1-\theta')de^{-(u_b+\varepsilon_b)}\frac{(u_b+\varepsilon_b)^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \\
&+a\theta de^{-(u_b+\varepsilon_b+\Delta_b)}\frac{(u_b+\varepsilon_b+\Delta_b)^B}{B!}e^{-(\varepsilon_s+\Delta_s)}\frac{(\varepsilon_s+\Delta_s)^S}{S!},
\end{aligned}
$$

where $B(S)$ is the number of buys (sells) for a given day, $\theta(\theta')$ is the probability of a symmetric order-flow shock conditional on the absence (arrival) of private information, $\Delta_b(\Delta_s)$ is the additional arrival rate of buys (sells) in the event of symmetric order-flow shock, $\varepsilon_b(\varepsilon_s)$ is the arrival rate of buy (sell) orders submitted by uninformed traders, a is the probability of an information event occurring during a trading day, d is the probability of good news, $(1-d)$ is the probability of bad news, $u_b(u_s)$ is the arrival rate of buy (sell) orders submitted by informed traders if the information event occurs, and $\vartheta = (a, u_b, u_s, \varepsilon_b, \varepsilon_s, d, \theta, \theta', \Delta_b, \Delta_s)$ is the vector of parameters.

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