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How Do Foreign Institutional Investors Enhance Firm Innovation?

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Abstract

We examine the effect of foreign institutional investors on firm innovation. Using firm-level data across 26 non-U.S. economies between 2000 and 2010, we show that foreign institutional ownership has a positive, causal effect on firm innovation. We further explore three possible underlying mechanisms through which foreign institutions affect firm innovation: Foreign institutions act as active monitors, provide insurance for firm managers against innovation failures, and promote knowledge spillovers from high-innovation economies. Our article sheds new light on the real effects of foreign institutions on firm innovation.

I. Introduction

Technological innovation determines a country's long-term economic growth (Solow (1957)). Despite various efforts to promote innovation, it remains a significant challenge for firms in economies outside the United States to engage in innovative activities.[1] Existing literature shows that firms' obstacles to innovation are often formed internally according to the country's culture and institutional environments (e.g., Acharya and Subramanian (2009), Brown, Martinsson, and

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[1]See Hsu, Tian, and Xu (2014) and Chang, McLean, Zhang, and Zhang (2015) for a stylized distribution of innovation output around (arounhae1nd)-pWour

Petersen (2013), Hsu et al. (2014), and Xie, Zhang, and Zhang (2016)).[2] In this study, we propose an external solution to overcome local firms' innovation constraints: foreign institutional investors. We investigate how foreign institutional investors affect firm innovation in non-U.S. economies.

We hypothesize that foreign institutional investors are able to enhance firm innovation. This conjecture is motivated by Aghion, Van Reenen, and Zingales's (2013) findings that institutional investors promote innovation in U.S. firms. Foreign institutional investors not only share common characteristics of financial institutions but also possess unique features that are different from those of domestic institutional investors. Specifically, foreign institutions are credited with their independence from local management, with holding internationally diversified portfolios, and with expertise in monitoring firms (e.g., Gillan and Starks (2003), Grinblatt and Keloharju (2000)). According to FactSet, foreign institutional ownership accounts for about 50% of total institutional ownership in non-U.S. firms, which is substantially different from that in the United States.[3] As an important force in non-U.S. economies, we expect that foreign institutions promote firms' innovation activities and strategies for at least three reasons.[4]

First, when the market cannot observe the full spectrum of managerial actions, moral hazard could induce managers to shirk and avoid investment in risky and costly innovative projects (Hart (1983), Bertrand and Mullainathan (2003)). Even worse, managers could divert firms' resources for their own private benefit and retain less capital for investment in innovative projects. Throughout this corporate capital-allocation process, institutional investors can act as corporate monitors and actively intervene to create firm value (e.g., Shleifer and Vishny (1986), Kahn and Winton (1998), Burkart, Gromb, and Panunzi (1997), and Gillan and Starks (2003)). Specifically, Gillan and Starks (2003) argue that because of their independent positions and a lack of conflicts of interest, foreign institutional investors play a more important role in corporate governance than domestic peers. This statement is further supported by Aggarwal, Erel, Ferreira, and Matos's (2011) finding that foreign institutional investors are proactively involved in monitoring investee firms worldwide. Therefore, we expect that intensive

[2]According to Carayannis, Samara, and Bakouros ((2015), p. 73), "in only a few cases the basic barriers are the scientific or technological problems. Usually, organizational, administrative, and institutional problems get in the way." Chen, Leung, and Evans (2016) find that a firm's treatment of its employees affects innovation.

[3]The ownership structure of U.S. firms is different from that of non-U.S. firms in the sense that foreign institutional ownership of U.S. firms accounts for just a negligible proportion of total equity ownership. For example, according to FactSet, foreign institutional investors hold merely 1.8%, whereas domestic institutions own as much as 38.4% for an average U.S. firm during the 2000–2010 period. To the best of our knowledge, the impact of institutional investors outside the United States, especially that of foreign institutions, on firm innovation is still largely unanswered in the literature.

[4]A famous recent anecdote supports the innovation-enhancing role of foreign institutional investors. Alibaba, a Chinese e-commerce company, raised $25 billion on Sept. 19, 2014, which is the world's largest initial public offering (IPO). Alibaba is regarded as one of the most innovative companies in China. Before Alibaba's IPO, it was financed by SoftBank (a Japanese investment company) and Yahoo (a U.S. technology firm), which later became Alibaba's largest and second largest shareholders, respectively. Due to Alibaba's IPO success in the United States, a question is frequently raised by the Chinese public and regulators: Why are innovative Chinese firms typically financed by foreign institutions?

monitoring by foreign institutions can induce managers to invest in long-term, value-enhancing innovative activities. We call this view the *monitoring channel*.

Second, optimal incentive contracts that motivate innovation should exhibit substantial tolerance for early failure and reward for long-term success (e.g., Manso (2011), Ederer and Manso (2013)). Aghion et al. (2013) state that if incentive contracts cannot fully motivate innovation, institutional investors could step in to alleviate managers' career or reputational concerns by providing them with insurance against early failures of their innovative activities. Compared with domestic peers, foreign institutional investors hold internationally diversified portfolios and thus should have a greater ability to tolerate the failure risk of investing in innovative projects. Therefore, they are more likely to insulate managers from punishment for innovation failures. We expect that the tolerance for failure by foreign institutions would encourage firm innovation. We term this view the *insurance channel*.

Third, investments in knowledge creation by one party create positive externalities in innovation on the other parties (Jaffe, Trajtenberg, and Fogarty (2000)).[5] Foreign institutions could facilitate knowledge spillovers through business networks.[6] For example, anecdotal evidence shows that foreign institutions can act as a bridge for networks of managers, investors, and other stakeholders of foreign and domestic firms to exchange opportunities and knowledge.[7] Moreover, given that foreign institutional investors promote cross-border mergers and acquisitions (Ferreira, Massa, and Matos (2010)), these cross-border investments could facilitate knowledge spillovers and further contribute to local firms' innovation activities (e.g., Guadalupe, Kuzmina, and Thomas (2012)). Taken together, foreign institutions could enhance knowledge spillovers across countries by promoting business networks and cross-border mergers and acquisitions, which could contribute to the success of innovation activities in investee firms. We call this view the *knowledge-spillover channel*.

We test our hypothesis using data from 26 non-U.S. economies for the 2000–2010 period. The data are from a unique international database of firm-level patents and citations, the Derwent World Patents Index (DWPI) compiled by Thomson Reuters. The existing cross-country studies on innovation typically use either research and development (R&D) expenditures from the Worldscope database or the number of patents granted by the U.S. Patent and Trademark Office (USPTO) as innovation measures. These measures, however, have some

[5]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 (Keller (2002)).

[6]Networks create value by synthesizing information and knowledge, exploiting expertise, and pooling resources across traditional boundaries to create new knowledge and achieve innovations outside of the individual capabilities and resource bases of individual organizations (Johnson, Heimann, and O'Neill (2001), Pawar and Sharifi (2000), Prasad and Akhilesh (2002), Ratcheva and Vyakarnam (2001), and Trott (2008)).

[7]For example, the chief executive officer (CEO) of BlackRock, a leading U.S. investment management company with investments in over 100 countries and offices in 30 countries, including India, offered to host a global investors meeting in India in early 2015.

likely to depend on a firm's innovation output. Our IV-approach analysis continues to find a positive effect of foreign institutional ownership on firm innovation.

We next examine three plausible underlying economic mechanisms through which foreign institutions enhance firm innovation. First, to test the monitoring channel, we classify foreign institutional investors into independent and gray investors, as well as long-term and short-term investors. Compared with gray (or short-term) foreign institutions, independent (or long-term) foreign institutions are regarded as active monitors that play a more important role in governing firms (e.g., Chen, Harford, and Li (2007)). Consistent with our conjecture, we find that only independent (or long-term) foreign institutions enhance firm innovation, whereas gray (or short-term) foreign institutions do not. Our evidence suggests that foreign institutional investors promote innovation through their active monitoring of firms.

Second, we explore the insurance channel. We find that the sensitivity of CEO turnover (or compensation) to performance is lower in firms with greater foreign institutional ownership. According to Manso (2011), a high sensitivity of CEO turnover (or compensation) to performance is detrimental to motivating firm innovation because these incentive contracts are intolerant of failure. Thus, this finding suggests that by providing insurance (against failure risk) to managers with career and reputational concerns, foreign institutional investors allow managers to focus more on long-term, risky investment in innovative projects and hence positively contribute to their investee firms' innovation output.

Finally, we examine the knowledge-spillover channel. To the extent that foreign institutions could act as a bridge that facilitates knowledge spillovers from their home countries to investee countries, we expect foreign institutions from more innovative countries to play a greater role in promoting investee firms' innovation than those from less innovative countries. Consistent with our hypothesis, we find that the positive effect of foreign institutional ownership on firm innovation is largely driven by institutions from foreign countries with a high innovation level.

Our article contributes to two strands of the literature. First, our article is related to the literature on the economic impacts of foreign institutions. Existing evidence shows that foreign institutional ownership affects firm value and performance (Ferreira and Matos (2008)), promotes improvements in governance (Aggarwal et al. (2011)), and facilitates the global convergence of financial reporting practices (Fang, Maffett, and Zhang (2015)). In addition, foreign ownership, in the aftermath of financial liberalization, affects the cost of capital (Bekaert and Harvey (2000), Lau, Ng, and Zhang (2010)), real wages (Chari, Henry, and Sasson (2012)), consumption growth volatility (Bekaert, Harvey, and Lundblad (2006)), emerging equity market volatility (Bekaert and Harvey (1997)), and stock market liquidity (Ng, Wu, Yu, and Zhang (2016)). Our study documents the positive role of foreign institutional ownership in promoting technological innovation. Our evidence is consistent with the findings of the contemporaneous article by Bena, Ferreira, Matos, and Pires (2017). Using a set of metrics such as tangible assets, intangible assets, human capital, and innovation output, they show that foreign institutional ownership fosters long-term investment. Our article differs from theirs by providing extensive evidence on firm innovation and by exploring possible underlying economic mechanisms through which foreign institutional investors enhance innovation.

Second, our article contributes to the emerging literature on finance and innovation by investigating an important driver of innovation outside the United States. There is a fast-growing body of literature that examines, both theoretically and empirically, various ways to promote innovation. Manso (2011) shows that managerial contracts that tolerate failure in the short run and reward success in the long run are best at motivating innovation. Empirical evidence shows that laws (Acharya and Subramanian (2009), Acharya, Baghai, and Subramanian (2014)), financial market development (Hsu et al. (2014)), firm boundaries (Seru (2014)), stock liquidity (Fang, Tian, and Tice (2014)), market conditions (Nanda and Rhodes-Kropf (2013)), financial analysts (He and Tian (2013)), banking competition (Cornaggia, Mao, Tian, and Wolfe (2015)), labor unions (Bradley, Kim, and Tian (2017)), product market competition (Aghion, Bloom, Blundell, Griffith, and Howitt (2005)), and corporate venture-capital investors (Chemmanur, Loutskina, and Tian (2014)) all alter agents' incentives and affect innovation. However, there is little insight into the causal effect of foreign institutional investors. We fill in this gap by showing that foreign institutional investors are an important driver of firm innovation, particularly in less innovative economies.

Our study complements the work of Aghion et al. (2013). In their model, institutional investors are assumed to affect stock prices through either the threat of exit or voice. Using a sample of U.S. firms, Aghion et al. (2013) show that institutional investors enhance firm innovation, which is consistent with the predictions of their model. Because the key assumptions of Aghion et al.'s (2013) model apply to an international setting, we expect institutional investors to have the same positive effect on firm innovation in non-U.S. countries.

Moreover, existing literature shows that compared with domestic institutions, foreign institutions are more likely to use their threat of exit and voice as disciplinary mechanisms. For example, Ahmadjian and Robbins (2005) find that foreign institutional investors in Japan use both exit and voice to send clear messages to management about their interests. In more general studies, Gillan and Starks (2003) argue that, due to their independent positions and a lack of conflicts of interest, foreign institutions play a crucial role in promoting governance changes in local firms. Aggarwal et al. (2011) find that foreign institutional investors engage in monitoring investee firms worldwide, which results in higher operating performance and firm value.

Thus, in the spirit of Aghion et al. (2013), we argue that, through the monitoring channel as well as the insurance channel, foreign institutional investors would contribute positively to firm innovation. Our study also explores a new underlying channel, unique to foreign institutions, that facilitates knowledge spillovers from more to less innovative countries. Taken together, our study complements the work of Aghion et al. (2013) by documenting the positive effect of foreign institutional ownership on firm innovation.

The article proceeds as follows: Section II describes the data and the variable construction. Section III presents our baseline results. Section IV addresses identification issues. Section V explores plausible underlying mechanisms. Section VI concludes.

II. Data, Variable Construction, and Descriptive Statistics

A. Data

Our sample includes publicly listed firms from 26 economies (excluding the United States) for the 2000–2010 period. We construct firm-level patent and citation variables based on the DWPI database compiled by Thomson Reuters. The DWPI is a comprehensive collection of global patent information in English, translated from over 30 languages. For example, in 2013, the DWPI contained patent data from 48 patenting authorities, covering 51 million patent documents and 23 million patent families across all innovation technologies.

We obtain institutional ownership data from the FactSet database, a leading source of global institutional ownership information. For non-U.S. firms, FactSet collects ownership data directly from sources such as national regulatory agencies, stock exchange announcements (e.g., the Regulatory News Service in the United Kingdom), 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, our sample period starts in 2000 and ends in 2010. We obtain firm accounting data from the Worldscope database.

To combine innovation, ownership, and accounting information from various databases, we match the DWPI's standardized assignee names with the names of public firms in Worldscope. We follow this procedure because the DWPI provides only firm names, not stock identifiers. Following procedures specified on the National Bureau of Economic Research (NBER) patent database's Web site, we start with all DWPI patents, as well as the universe of firms from Worldscope that have firm names and nonmissing Stock Exchange Daily Official List (SEDOL) codes (a SEDOL code is a 7-digit security identifier assigned by the London Stock Exchange).[9] We use both exact and fuzzy matching methods to match the DWPI's assignee names with those from Worldscope. To eliminate any lingering doubt in the data-matching process, we manually search for information about sample firms from different newswire services and Internet sources. In this process, we require a firm to have valid innovation and accounting information to be included in the sample. Finally, we require an economy to have at least 10 firms to be retained in the sample. Our final sample covers 4,249 unique non-U.S. firms from 26 economies (with a total of 30,008 firm-year observations), of which 1,506 firms are located in emerging economies and 2,743 firms in developed economies.

B. Variable Construction

1. Firm-Level Innovation Variables

Due to the lack of global patent data, prior studies either construct innovation measures based on R&D expenditures from Worldscope or use patents applied for through the USPTO as a proxy for a firm's total innovation output (e.g., Hsu et al. (2014)). According to the National Research Council (2014), although R&D expenditures are an important input of the innovation process, they

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

cannot adequately substitute for the innovation output. First, many firms do not report R&D expenditures in their financial statements due to differences in accounting standards among countries. However, missing R&D information does not necessarily mean that firms are not involved in innovative activities (Koh and Reeb (2015)).

Second, not all R&D investments lead to patent granting because only successful or significant innovation is patentable. According to the World Intellectual Property Organization (WIPO), “the invention must consist of patentable subject matter, the invention must be industrially applicable (useful), it must be new (novel), it must exhibit a sufficient ‘inventive step’ (be nonobvious), and the disclosure of the invention in the patent application must meet certain standards” ((2004), p. 17). Our use of patents as a measure of innovation output or successful patent applications captures an important dimension of innovation and thus is complementary to the use of R&D investments in measuring innovative activities.

Third, many non-U.S. firms may not apply for patents to the USPTO, which results in an underestimation of innovation output using only U.S. patents as a proxy for non-U.S. firms’ total innovation output.[10] Comparing the USPTO with the DWPI, we find that the latter compiles more patents than the former, especially for innovative economies. For example, in Japan, there are a total of 212,034 (285,283) patents filed by Japanese firms in the USPTO (DWPI), which suggests that about 25% of Japanese patents in the DWPI are not covered in the USPTO. Regarding Germany, there are a total of 29,484 (35,528) patents from the USPTO (DWPI), which suggests that about 17% of awarded patents of German firms covered in the DWPI are not from the USPTO. We observe similar patterns in other economies, such as Korea and Taiwan.[11] The DWPI database contains information on all patents applied for through patent offices around the world. Therefore, we are able to construct more accurate measures for non-U.S. firm innovation using this database. From the DWPI database, we obtain information on patent assignee names, application numbers, application dates, application countries, the number of future citations received by each patent, patent grant dates, and grant countries.

We construct two measures to capture firm innovation. The first one is a firm’s total number of patent applications that are eventually granted in a given year; this measure captures a firm’s innovation quantity. We use a patent’s application year instead of its grant year because the former is superior when capturing the actual time of innovation (Griliches, Pakes, and Hall (1988)). To account for the fact that a patent can be assigned to multiple assignees in the DWPI database, we scale a patent by the number of assignees that own the patent,

[10]There are two plausible reasons why many non-U.S. firms do not apply for patents through the USPTO. First, these non-U.S. firms may not do business in the United States. According to the U.S. patent law, patents filed to the USPTO are protected in the United States but not in other countries. As a result, firms that do not do business in the United States and hence do not need their intellectual property to be protected in the United States do not apply for patents through the USPTO. Second, “home bias” in patenting due to patent policy familiarity and geographical distance could be another reason. Chang et al. (2015) find that about 39.1% of the patents owned by firms are awarded within a firm’s home country and that 76.3% of non-U.S. patents are filed in.htsideuntry th another

assuming equal patent ownership. Because a patent may belong to more than one technology group, we further scale this measure by the mean number of patent applications filed in a year for technology groups to which the patent belongs. The DWPI database classifies all patents into 3 broad categories (chemical, engineering, and electronic and electrical engineering), which are further divided into 20 broad subject areas (see Appendix A for details). We use these 20 patent groups to normalize our first innovation measure.

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

We address several concerns regarding the innovation variables calculated based on the DWPI data set. The first one is the truncation problem caused by the fact that patents appear in the database only after they are granted. Because the lag between a patent's application year and its grant year is significant (about 2 years on average), many patent applications were still under review and had not been granted by 2015 (when we retrieved the data). To adjust the truncation bias in patent counts, we end our study period in 2010, which allows 5 more years for patents under review to be granted. Another truncation problem is related to patent citations. Patents keep receiving citations over a long period (e.g., 60 years), but we observe citations received only up to 2015. Following Hall, Jaffe, and Trajtenberg (2001), we address the truncation bias in citation counts by scaling the number of citation counts by the mean citation counts of the patent in the technology groups to which the patent belongs.

Second, we avoid the double-counting problem, that is, a firm may submit patent applications to and be granted patents by more than one patenting authority based on the same invention. The DWPI database allows us to retrieve patents that are based on the same invention and are granted by all patenting authorities. For the same invention's patents, we keep the record of the earliest grant date and count the number of unique patents.

The third issue is the right skewness of the distribution of patent grants and future citations in our sample with its median at 0. This observation is similar to what has been documented in the innovation literature (e.g., Acharya et al. (2014), Seru (2014), and Tian and Wang (2014)). To address the right skewness of patent and citation count distributions, we winsorize these two variables at the 99th percentile and then use the natural logarithms of patents and citations as our main innovation measures. To avoid losing firm-year observations with 0 patents or citations, we add 1 to the actual patent values before taking the natural logarithm.

2. Institutional Ownership

Following the literature on institutional investors (e.g., Gompers and Metrick (2001), Aggarwal et al. (2011)), we use institutional ownership at the latest report date of a calendar year and construct ownership variables as follows. Foreign institutional ownership (FIO) is the sum of shares held by all institutions domiciled in a different country from where the firm's stock is listed, as a percentage of the firm's total number of shares outstanding. We set FIO to 0 if a stock is not held by any foreign institution. Similarly, domestic institutional ownership (DIO) is the sum of shares held by all institutions domiciled in the same country as the one where the firm's stock is listed, as a percentage of the firm's total number of shares outstanding. We set DIO to 0 if a stock is not held by any domestic institution.

3. Control Variables

Following the literature on innovation, we control for a full set of firm and country characteristics that can affect a firm's innovation output. At the firm level, we use firm size (ln(SALE)), firm age (ln(AGE)), investments in intangible assets (RD), capital expenditures (CAPEX), asset tangibility (PPE), leverage (LEV), profitability (ROA), financial constraints (the Kaplan and Zingales (KZ) (1997) index), and growth opportunities (TOBINS_Q). We also include industry concentration (the Herfindahl index (HHI) and the squared Herfindahl index (HHI^2)) to mitigate the nonlinear effects of product market competition on innovation output (Aghion et al. (2005)). In addition, we add the percentage of foreign sales in total sales (FSALE) as a firm-level control variable because MacGarvie (2006) suggests that a firm's innovation may be related to its export and import markets. Last, we also control for insider ownership (INSIDE) because managers may have stronger incentives and greater power to pursue innovative projects when insider ownership increases. We winsorize all firm-level variables at the 1st and 99th percentiles to eliminate the effects of outliers.

At the country level, we adopt several controls drawn from the literature that may be related to firm innovation. Specifically, we follow Aghion, Howitt, and Prantl (2015) to control for the patent regulatory environment by using the patent right protection index of Park (2008) (P_INDEX). We also use 2 dimensions of worldwide governance indicators, namely, the rule of law (RULE) and the government effectiveness (GOODGOV) constructed by Kaufmann, Kraay, and Mastruzzi (2011), as additional controls for country-level institutions. Because Hsu et al. (2014) find that financial development is related to innovation, we control for equity market development, using the ratio of a country's stock market capitalization to its gross domestic product (GDP) (EQUITY) and its credit market development, which is the ratio of a country's domestic credit to its GDP (CREDIT). Finally, we follow Acharya and Subramanian (2009) to control for a country's GDP per capita (ln(GDP)) and its levels of exports (EXPORT) and imports (IMPORT), defined as the ratios of exports and imports to its GDP, respectively. Appendix B provides detailed variable definitions.

C. Summary Statistics

Table 1 presents sample statistics. Panel A of Table 1 reports the means of innovation measures and institutional ownership by economy. PATENT refers to the total number of patent applications that are filed Sre evenetu patents per year (25), followed by firms in Germany (21), Korea (18), the Netherlands (15), Taiwan (12), and Switzerland (12). The pattern is broadly similar for citations. On average, a firm in a developed economy has a larger number of both patents and citations (17 and 28, respectively) than one in an emerging economy (12 and 25, respectively). For institutional ownership, an average firm in a developed economy has an FIO that is just about the same as the DIO (5.1% and 5.0%, respectively), whereas the FIO of an average firm in an emerging economy is substantially higher than its DIO (3.6% vs. 0.7%); for the entire sample, FIO is generally greater than DIO.

Panel B of Table 1 presents the summary statistics of firm and country characteristics. On average, a firm has a book value of assets of $315.7 million, a ratio of R&D to assets of 3.2%, a ratio of capital expenditures to assets of 5.5%, a ratio of PPE to assets of 28.6%, a leverage ratio of 21.3%, an ROA of 7.4%, and a TOBINS_Q of 1.57. The average length of time that a firm has been listed on a stock exchange is 14.5 years.

TABLE 1

Summary of Firm Innovation and Institutional Ownership

Table 1 reports the sample statistics for the 2000–2010 period. Panel A reports the means of innovation and institutional ownership sample data by country. Type of Market reports whether the economies are developed (DEV) or emerging (EMG) economies. No. of Firms is the number of firms in each sample country. No. of Firm-Years is the number of firm-year observations. PATENT is the total number of patent applications filed by each firm in each year. CITEPAT 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- and country-level variables. Details of variable definitions are in Appendix B.

Panel A. Firm Innovation and Institutional Ownership by Country

				Innovation		Institutional Ownership	
Country	Type of Market	No. of Firms	No. of Firm-Years	PATENT	CITEPAT	FIO	DIO
Australia	DEV	120	730	0.886	2.697	4.220	1.347
Austria	DEV	29	205	1.676	2.710	9.125	1.860
Belgium	DEV	23	173	11.327	27.638	11.038	3.310
Brazil	EMG	46	313	1.324	2.782	7.972	0.373
Canada	DEV	246	1,579	1.954	4.272	9.589	13.996
Denmark	DEV	19	231	6.547	31.353	7.932	10.826
Finland	DEV	49	399	2.033	7.638	11.406	8.998
France	DEV	215	1,466	9.194	13.053	6.903	4.539
Germany	DEV	243	1,716	20.704	32.997	7.743	4.719
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	183	1,080	3.422	12.637	3.713	3.114
Israel	EMG	62	343	1.708	4.123	18.997	1.029
Italy	DEV	66	461	3.059	4.542	7.566	2.605
Japan	DEV	1,309	11,209	25.451	40.599	2.747	2.369
Korea	EMG	591	3,173	18.452	33.157	3.479	0.107
Netherlands	DEV	20	160	14.721	21.250	18.668	4.631
New Zealand	DEV	12	74	1.027	0.930	1.155	0.524
Norway	DEV	47	267	2.404	4.506	8.722	10.223
Singapore	DEV	36	291	1.218	1.594	5.460	1.083
South Africa	EMG	16	120	0.267	0.193	8.429	4.197
Spain	DEV	23	191	0.803	0.508	6.796	4.687
Sweden	DEV	85	596	4.552	7.485	6.856	12.721
Switzerland	DEV	40	323	12.251	29.860	9.891	6.039
Taiwan	EMG	594	3,700	12.319	26.095	2.306	0.287
United Kingdom	DEV	148	1,041	2.772	6.727	4.596	19.056
Developed	DEV	2,743	21,213	16.841	27.514	5.052	5.036
Emerging	EMG	1,506	8,795	12.379	24.755	3.834	0.656
All economies	ALL	4,249	30,008	15.533	26.705	4.695	3.753

(continued on next page)

TABLE 1 (continued)
Summary of Firm Innovation and Institutional Ownership

Panel B. Summary Statistics

Variables	No. of Firms	No. of Firm-Years	Mean	Std. Dev.	P25	Median	P75
Innovation Variables							
PATENT	4,249	30,008	15.533	61.319	0.000	0.000	3.000
CITEPAT	4,249	30,008	26.705	106.483	0.000	0.000	3.460
ln(PATENT)	4,249	30,008	0.904	1.427	0.000	0.000	1.386
ln(CITEPAT)	4,249	30,008	0.957	1.670	0.000	0.000	1.495
Ownership Variables							
FIO	4,249	30,008	4.695	8.779	0.000	0.937	5.585
FIO_{US}	4,249	30,008	2.380	6.245	0.000	0.269	1.949
FIO_{NONUS}	4,249	30,008	2.316	4.418	0.000	0.247	2.840
FIO_{LONG_TERM}	4,249	30,008	4.561	8.583	0.000	0.835	5.388
FIO_{SHORT_TERM}	4,249	30,008	0.135	0.850	0.000	0.000	0.028
$FIO_{INDEPENDENT}$	4,249	30,008	4.443	8.456	0.000	0.852	5.203
FIO_{GRAY}	4,249	30,008	0.252	0.657	0.000	0.000	0.153
$FIO_{HIGH\_PATENT\_GDP}$	4,249	30,008	3.980	7.971	0.000	0.674	4.458
$FIO_{LOW\_PATENT\_GDP}$	4,249	30,008	0.715	1.681	0.000	0.000	0.636
$FIO_{HIGH\_PATENT\_POP}$	4,249	30,008	4.403	8.442	0.000	0.826	5.128
$FIO_{LOW\_PATENT\_POP}$	4,249	30,008	0.292	0.952	0.000	0.000	0.080
$FIO_{HIGH\_PATENT\_FIRMS}$	4,249	30,008	4.166	8.225	0.000	0.711	4.711
$FIO_{LOW\_PATENT\_FIRMS}$	4,249	30,008	0.530	1.514	0.000	0.000	0.300
$FIO_{HIGH\_PATENT\_MCAP}$	4,249	30,008	2.710	6.519	0.000	0.341	2.447
$FIO_{LOW\_PATENT\_MCAP}$	4,249	30,008	1.985	3.881	0.000	0.182	2.418
DIO	4,249	30,008	3.753	7.254	0.000	0.577	4.347
Control Variables							
ln(TA)	4,249	30,008	5.755	1.984	4.393	5.555	6.968
AGE	4,249	30,008	14.528	10.634	6.000	12.000	20.000
ln(SALE)	4,249	30,008	5.587	2.172	4.257	5.518	6.963
FSALE	4,249	30,008	0.212	0.355	0.000	0.000	0.373
INSIDE	4,249	30,008	0.273	0.260	0.000	0.244	0.467
HHI	4,249	30,008	0.252	0.259	0.072	0.145	0.338
HHI^2	4,249	30,008	0.130	0.246	0.005	0.021	0.114
RD	4,249	30,008	0.032	0.067	0.000	0.008	0.033
CAPEX	4,249	30,008	0.055	0.052	0.019	0.040	0.072
PPE	4,249	30,008	0.286	0.181	0.142	0.271	0.405
LEV	4,249	30,008	0.213	0.180	0.053	0.190	0.328
ROA	4,249	30,008	0.074	0.119	0.044	0.089	0.137
TOBINS_Q	4,249	30,008	1.570	1.392	0.922	1.151	1.636
KZ	4,249	30,008	−7.351	23.848	−4.828	−1.069	0.647
P_INDEX	4,249	30,008	4.370	0.451	4.170	4.670	4.670
GOODGOV	4,249	30,008	1.338	0.470	1.120	1.420	1.620
RULE	4,249	30,008	1.227	0.438	0.970	1.290	1.550
EXPORT	4,249	30,008	0.324	0.265	0.143	0.263	0.421
IMPORT	4,249	30,008	0.300	0.238	0.129	0.278	0.371
EQUITY	4,249	30,008	0.896	0.446	0.613	0.790	1.085
CREDIT	4,249	30,008	1.372	1.368	0.000	1.255	3.020
ln(GDP)	4,249	30,008	10.207	0.502	10.248	10.320	10.376

III. Baseline Regression Results

To examine the relation between foreign institutional ownership and firm innovation, we estimate various forms of the following model using pooled ordinary least squares (OLS) regressions:

$$(1) \quad \text{INNOVATION}_{ijt} = \alpha + \beta_1 \text{FIO}_{ijt-1} + \beta_2 \text{DIO}_{ijt-1} + \gamma' X_{ijt-1} + \phi_i + \psi_k + \omega_j + \varphi_t + \varepsilon_{ijt},$$

where i, k, j, and t refer to firm, industry, country, and year, respectively. The dependent variable (INNOVATION) captures firm innovation outcomes: The natural logarithm of 1 plus the number of patents (ln(PATENT)) reflects innovation quantity; the natural logarithm of 1 plus the number of citations per patent (ln(CITEPAT)) captures innovation quality. We measure both foreign and domestic institutional ownership in year $t-1$. X denotes a vector of firm and country characteristics, as discussed in Section II.B.3, which are measured in year $t-1$. We include year fixed effects (φ) and firm fixed effects (ϕ) (or industry fixed effects (ψ) and country fixed effects (ω)) in various specifications. In all regressions, we report in parentheses robust standard errors clustered at the firm level.

Columns 1 and 2 of Table 2 report the results from pooled OLS regressions controlling for industry, country, and year fixed effects. The coefficient estimates on FIO are positive and significant at the 1% level across all specifications, suggesting a positive relation between foreign institutional ownership and innovation output. In terms of economic significance, a coefficient estimate of 0.010 (0.014) in model 1 (model 2) suggests that an increase in foreign institutional ownership from the 25th percentile to the 75th percentile of its distribution is associated with a 5.6% (7.8%) increase in the number of patents (citations per patent) in the following year.[12] This result is economically significant.

Although the pooled OLS regression results show a positive association between foreign institutional ownership and firm innovation, one concern is that these results could be driven by omitted variables. To alleviate this concern, we include firm fixed effects (and drop industry and country fixed effects because they do not vary within a firm) in the regressions and report the results in columns 3 and 4 of Table 2. Firm fixed effects absorb time-invariant unobservable firm characteristics that affect both foreign institutional ownership and firm innovation. Once again, we find that the coefficient estimates on FIO remain positive and significant at the 1% level in all specifications. The magnitudes of the FIO coefficient estimates become slightly smaller in columns 3 and 4 but are still comparable to those in columns 1 and 2. This evidence suggests that our baseline finding is not driven by time-invariant, unobservable firm characteristics.

Regarding firm-level control variables, the coefficient estimates on DIO are not uniformly significant across different model specifications, suggesting that there is no clear evidence for the effect of domestic institutional investors on firm innovation in non-U.S economies. One possible explanation for this result is that domestic institutional investors in non-U.S. economies may not satisfy the model assumptions of Aghion et al. (2013); that is, they are weak at monitoring managers and do not effectively provide managers with insurance against failure. This argument is generally supported by the existing literature.[13]

[12]This way of quantifying the size of the effect of foreign institutional ownership is consistent with several studies on institutional ownership, such as those by Chung and Zhang (2011) and Wahal and McConnell (2000).

[13]For example, Douma, George, and Kabir (2006) document that domestic institutional investors in India are predominantly government owned, which significantly reduces their monitoring incentives due to several problems; for example, the government's nominees on the board are typically bureaucrats with minimal expertise in corporate matters. Similarly, Ahmadjian and Robbins (2005) document that Japanese institutional investors are less likely to exercise exit or voice because, as compared with foreign investors, they have very different interests and relationships with the companies whose shares they hold. Trust banks, usually close affiliates of commercial banks, are unlikely to do anything to undermine the banks' interests. Pension funds are hesitant to make demands on suppliers or customers. Life insurance companies, among the largest shareholders in the Japanese economy, tend to make money by selling insurance to employees of corporations in which they have ownership stakes. Banks are also unlikely to promote restructuring actively.

TABLE 2
Baseline Regressions

Table 2 reports the regressions of firm innovation on institutional ownership. Columns 1 and 2 (3 and 4) show the pooled ordinary least squares (OLS) (Firm fixed effects) regression results. The dependent variable is shown as the column heading in columns 1–4. The main independent variable is foreign institutional ownership (FIO). All explanatory variables are lagged by 1 year. Variable definitions are in Appendix B. Standard errors are clustered at the firm level and reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	ln(PATENT)	ln(CITEPAT)	ln(PATENT)	ln(CITEPAT)
Variables	1	2	3	4
FIO	0.010***	0.014***	0.008***	0.011***
	(0.003)	(0.004)	(0.003)	(0.004)
DIO	−0.010***	−0.012***	−0.001	−0.001
	(0.002)	(0.003)	(0.001)	(0.002)
INSIDE	−0.072	−0.054	0.062*	0.084*
	(0.063)	(0.070)	(0.032)	(0.044)
ln(AGE)	0.062**	0.062*	0.086**	0.118**
	(0.029)	(0.032)	(0.037)	(0.049)
HHI	0.396	0.400	−0.170	0.152
	(0.292)	(0.326)	(0.274)	(0.347)
HHI^2	−0.277	−0.280	0.152	0.050
	(0.277)	(0.307)	(0.241)	(0.290)
RD	2.267***	2.637***	0.054	−0.232
	(0.238)	(0.288)	(0.132)	(0.215)
CAPEX	2.313***	2.913***	0.378***	0.519***
	(0.269)	(0.308)	(0.134)	(0.184)
PPE	−0.232**	−0.192	−0.082	−0.095
	(0.116)	(0.129)	(0.086)	(0.114)
LEV	−0.365***	−0.453***	−0.132**	−0.185***
	(0.097)	(0.104)	(0.057)	(0.070)
ROA	−0.616***	−0.850***	−0.037	−0.169
	(0.144)	(0.165)	(0.079)	(0.108)
FSALE	0.138**	0.169*	0.000	−0.009
	(0.067)	(0.088)	(0.020)	(0.018)
ln(SALE)	0.276***	0.317***	0.110***	0.115***
	(0.016)	(0.018)	(0.015)	(0.020)
TOBINS_Q	0.071***	0.099***	0.005	0.001
	(0.011)	(0.014)	(0.005)	(0.008)
KZ	−0.002***	−0.003***	−0.001***	−0.001***
	(0.001)	(0.001)	(0.000)	(0.000)
P_INDEX	0.115**	0.186***	0.116***	0.150**
	(0.047)	(0.064)	(0.045)	(0.062)
RULE	0.098	0.051	−0.033	−0.081
	(0.080)	(0.100)	(0.071)	(0.093)
GOODGOV	0.128**	0.116*	0.131***	0.131**
	(0.053)	(0.066)	(0.049)	(0.062)
EXPORT	0.283	0.096	−0.027	−0.117
	(0.409)	(0.498)	(0.383)	(0.465)
IMPORT	0.886**	0.555	0.793*	0.483
	(0.440)	(0.549)	(0.406)	(0.517)
EQUITY	0.078**	0.012	0.089***	0.0672

For other firm-level control variables, the coefficient estimates on INSIDE are positive and significant in firm fixed effects regressions, which suggests that insider ownership is positively associated with firm innovation. Larger and older firms are associated with higher innovation output. Firms with higher capital expenditures have more innovation output. Firms with higher leverage are associated with lower innovation output. Financial constraints are negatively related to innovation output. All these results are consistent with earlier work (e.g., see Hall and Lerner (2010) for a survey).

As for country-level control variables, firms in countries with stronger patent regulatory environments are associated with higher innovation output. Similarly, firms located in countries with a higher government effectiveness index or with developed stock markets have higher innovation output. We find weaker evidence for the effect of exports and imports and GDP per capita on firm innovation.

We conduct a few robustness checks. First, because Japanese and Taiwanese firms are much larger in the number of firms than the rest of our sample firms, we exclude firms in these two economies from the regressions. We continue to find a positive relation between foreign institutional ownership and firm innovation. We next use a dummy variable to capture large foreign institutional ownership, which equals 1 if foreign institutional ownership is greater than 5%, and 0 otherwise. We find that foreign institutional investors holding more than 5% of equity ownership in a firm are positively related to firm innovation. We report these results in Tables A1 and A2 in the Internet Appendix (available at www.jfqa.org).

Overall, our baseline regression results suggest a positive relation between foreign institutional ownership and firm innovation, consistent with our hypothesis that foreign institutional ownership enhances firm innovation.

IV. Identification Attempts

Our evidence so far suggests a positive relation between foreign institutional ownership and firm innovation. Although our results are robust to the inclusion of firm fixed effects that absorb time-invariant unobservables, the finding may still be subject to endogeneity concerns because time-varying, unobservable firm characteristics omitted from the regression could bias the inference. Reverse causality is another concern. It is possible that firms with high innovation potential attract foreign institutional investors. Hence, the direction of causality goes from innovation to foreign institutional ownership. In this section, we attempt to address these identification concerns by using 2 identification strategies: a DID approach and an instrumental variable approach.

A. Difference-in-Differences Approach

Our first identification strategy is to exploit a quasi-natural experiment that generates plausibly exogenous variation in foreign institutional ownership: the passage of JGTRRA of 2003. JGTRRA substantially lowered dividend tax rates (from 38.6% to 15%) not just for U.S. firms but also for firms domiciled in countries that have tax treaties with the United States. Dividends from firms in nontreaty countries, however, remain taxable at the ordinary personal income tax rate after the passage of JGTRRA (e.g., 35% for the top income tax bracket). Therefore, nontreaty economies, which include Brazil, Hong Kong, Singapore, and Taiwan, do not receive this favorable tax treatment.[14] We then use a DID approach that compares the innovation output of treatment firms with that of control

Because the validity of the DID depends on the parallel-trend assumption, we perform 3 diagnostic tests to verify that this assumption is not violated. In the first diagnostic test, we report, in Panel A of Table 3, the univariate comparisons between the pre-JGTRRA innovation growth variables of treatment firms and those of control firms and their corresponding t-statistics. Pre-JGTRRA innovation growth variables are not significantly different between treatment and control firms. These results suggest that there is no observable pre-JGTRRA trend in innovation outcomes between the two groups of firms, suggesting the satisfaction of the parallel-trend assumption.

In the second diagnostic test, we plot the average logarithm of the number of patents (citations per patent) for treatment and control firms over a 7-year period around the passage of JGTRRA in Graph A (B) of Figure 1. As one can observe, the two lines trend closely in parallel in the years leading up to the passage of JGTRRA, which suggests the satisfaction of the parallel-trend assumption. In addition, after the passage of JGTRRA, the line representing treatment firms begins to trend upward across the line representing control firms, suggesting that treatment firms experience an increase in innovation output.

In the third test, we reestimate the probit model, restricted to the matched sample, and find that the coefficient estimates of the pre-JGTRRA innovation growth variables ($\text{GROWTH}_{\text{PATENT}}$ and $\text{GROWTH}_{\text{CITEPAT}}$) are not statistically significant. We report this test in Table A4 of the Internet Appendix. Overall, these diagnostic tests suggest that the propensity-score-matching process reasonably removes meaningful observable differences in the covariates between treatment and control firms.

TABLE 3

Difference-in-Differences Analysis

Table 3 reports the diagnostics and results of the difference-in-differences (DID) tests on how a plausibly exogenous shock to foreign institutional ownership due to the passage of the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) in 2003 affects firm innovation. Treatment firms must pay dividends in the year before the tax cut (2002) and be domiciled in treaty countries. Control firms must be domiciled in nontreaty countries and pay dividends in the year before the tax cut (2002). Each control firm is then matched to 5 treatment firms using the nearest-neighbor propensity-score-matching procedure, on a vector of firm- and country-level characteristics as in the baseline regression, and innovation growth variables ($\text{GROWTH}_{\text{PATENT}}$ and $\text{GROWTH}_{\text{CITEPAT}}$) over 3 years before the tax cut. Panel A reports the univariate comparison between innovation growth variables of treatment firms and those of control firms and their corresponding t-statistics. Panel B reports the univariate DID estimators, with standard errors displayed in parentheses. Panel C reports the multivariate DID test results, with standard errors adjusted for firm-level clustering displayed in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Differences in Innovation Growth Variables

Variables	Treatment	Control	Differences	t-Statistics
$\text{GROWTH}_{\text{PATENT}}$	0.468	0.391	0.077	1.56
$\text{GROWTH}_{\text{CITEPAT}}$	0.363	0.301	0.062	1.15

Panel B. Difference-in-Differences Test

Variables	Treatment After − Before 1	Control After − Before 2	Treatment − Control DID Estimator 3	t-Statistics for DID 4
ln(PATENT)	0.178 (0.047)	0.079 (0.035)	0.099**	2.215
ln(CITEPAT)	0.205 (0.054)	0.082 (0.033)	0.123***	2.849

(continued on next page)

TABLE 3 (continued)
Difference-in-Differences Analysis

Panel C. Multivariate Difference-in-Differences Test

	FIO_{US}		ln(PATENT)		ln(CITEPAT)	
Variables	1	2	3	4	5	6
TREAT × POST	1.501***	1.089***	0.109***	0.091***	0.121***	0.115***
	(0.076)	(0.079)	(0.020)	(0.022)	(0.029)	(0.033)
FIO_{NONUS}		0.091***		0.017**		0.021*
		(0.022)		(0.007)		(0.011)
DIO		0.018**		−0.002		−0.009
		(0.009)		(0.005)		(0.008)
INSIDE		0.194		0.094		0.077
		(0.181)		(0.092)		(0.123)
ln(AGE)		−0.058		0.338***		0.243**
		(0.152)		(0.071)		(0.108)
HHI		1.250		1.013*		0.753
		(1.286)		(0.586)		(0.883)
HHI^2		−1.229		−0.751		−0.591
		(1.240)		(0.512)		(0.837)
RD		−0.648		0.621		0.002
		(1.527)		(0.851)		(1.164)
CAPEX		0.487		0.261		0.135
		(0.673)		(0.303)		(0.483)
PPE		0.915*		0.280		0.090
		(0.469)		(0.195)		(0.301)
LEV		0.077		−0.240		−0.277
		(0.362)		(0.174)		(0.254)
ROA		−0.695		−0.767***		−0.504
		(0.578)		(0.292)		(0.393)
FSALE		−0.161		0.098		−0.139
		(0.247)		(0.101)		(0.166)
ln(SALE)		0.578***		0.111***		0.137***
		(0.113)		(0.037)		(0.042)
TOBINS_Q		0.055		−0.040**		−0.066**
		(0.038)		(0.018)		(0.029)
KZ		0.003		−0.002*		−0.002*
		(0.002)		(0.001)		(0.001)
P_INDEX		0.049		0.246***		0.386***
		(0.187)		(0.071)		(0.136)
RULE		−0.392		−0.212		0.031
		(0.323)		(0.137)		(0.197)
GOODGOV		0.884***		0.144		0.159
		(0.267)		(0.107)		(0.165)
EXPORT		6.209***		0.143		−2.502**
		(2.032)		(0.738)		(1.072)
IMPORT		−6.101***		−0.454		3.039**
		(2.213)		(0.916)		(1.355)
EQUITY		0.162		0.194**		0.350***
		(0.218)		(0.086)		(0.136)
CREDIT		0.114		−0.016		−0.024
		(0.071)		(0.032)		(0.045)
ln(GDP)		0.570		0.293*		0.002
		(0.360)		(0.153)		(0.246)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.821	0.839	0.844	0.867	0.800	0.826
No. of obs.	4,788	4,788	4,788	4,788	4,788	4,788

FIGURE 1

Innovation Output of Treatment and Control Firms Surrounding JGTRRA

Figure 1 shows the average innovation output of the treatment and control firms from 3 years before to 3 years after the passage of the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) in 2003. The event year is denoted as year 0 (2003). The sample contains 456 unique treatment firms and 228 unique control firms. Graph A reports the mean natural logarithm of the total number of patents (ln(PATENT)), and Graph B reports the mean natural logarithm of the total number of citations per patent (ln(CITEPAT)).

Graph A. ln(PATENT)

Panel B of Table 3 presents the results of the univariate DID test. We compute DID estimators for innovation variables by first subtracting the average number of patents (citations) over the 3-year period preceding the passage of JGTRRA from the average number of patents (citations) over the 3-year period after the passage of JGTRRA for each treatment and control firm. We then average the difference over the 2 groups and report the results in columns 1 and 2, respectively. In columns 3 and 4, we report the DID estimates and the corresponding t-statistics with the null hypothesis that the DID estimates are 0, respectively.

The results in columns 3 and 4 of Panel B show that the DID estimators are positive and significant at the 1% level, suggesting that the increase in innovation output is significantly larger for the treatment group than for the control group during the period from 3 years before to 3 years after the passage of JGTRRA. The magnitudes of the DID estimates are economically significant as well. For example, the DID estimate on ln(PATENT) is 0.099, suggesting that treatment firms experience an increase of 11% in ln(PATENT) relative to the mean ln(PATENT) of control firms (0.853) surrounding the passage of JGTRRA. Similarly, the DID estimator for ln(CITEPAT) is 0.123, indicating that treatment firms experience an increase of 14% in ln(CITEPAT) relative to the mean ln(CITEPAT) of control firms (0.850) surrounding the passage of JGTRRA.

Next, we perform the DID tests in a multivariate regression framework by estimating the following model:

$$\text{(2)} \qquad \text{INNOVATION}_{it} \;\; \text{FIO}_{\text{US}_{it}} = \alpha + \beta \text{TREAT}_i \times \text{POST}_t + \gamma' X_{it-1} + \phi_i + \varphi_t + \varepsilon_{it},$$

where the dependent variable INNOVATION captures firm innovation outcomes: the natural logarithm of 1 plus the number of patents (ln(PATENT)); the natural logarithm of 1 plus the number of citations received by each patent (ln(CITEPAT)). The dependent variable FIO_{US} captures U.S. foreign institutional ownership. TREAT is a dummy variable that equals 1 for treatment firms, and 0 for control firms. POST is a dummy variable that equals 1 if the fiscal year is after 2003, and 0 otherwise. X consists of non-U.S. foreign institutional ownership and a vector of firm- and country-level control variables used in equation (1). ϕ_i and φ_t represent firm fixed effects and year fixed effects, respectively.[17] The coefficient estimate on TREAT × POST is the DID estimator that captures the causal effect of U.S. foreign institutional ownership on firm innovation.[18]

Panel C of Table 3 reports the regression results estimating equation (2) with standard errors clustered at the firm level. In models 1 and 2, where the dependent variables are FIO_{US}, the coefficient estimates on TREAT × POST are positive and statistically significant, which suggests that treatment firms, on average, experience an increase in U.S. foreign institutional ownership following the passage of JGTRRA. For example, a coefficient estimate of 1.501 in model 1 suggests that U.S. foreign institutional ownership in treatment firms is 1.5% higher than that in control firms subsequent to the passage of JGTRRA. In models 3–6, where the dependent variables are ln(PATENT) or ln(CITEPAT), the coefficient estimates on TREAT × POST are positive and significant at the 1% level, which suggests that treatment firms, on average, experience a larger increase in innovation output than control firms following the passage of JGTRRA. A coefficient estimate of 0.091 (0.115) in model 4 (model 6) suggests that, compared with the control group, the treatment group experiences an increase of 9.1% (11.5%) in the number of patents (the number of citations per patent).

To ensure that our DID test results are robust, we conduct a few more tests. First, because it is plausible that firms anticipate the passage of JGTRRA, our selection of treatment and control firms that pay dividends 1 year in advance of the event could still be subject to potential endogeneity. To address this concern,

[17]TREAT and POST are absorbed by firm fixed effects and year fixed effects.

[18]When we run a similar regression with $\text{FIO}_{\text{NONUS}}$ being the dependent variable, we find that the coefficient estimate on TREAT × POST is not significant. We report the results in Panel B of Table A3 in the Internet Appendix.

(2010) find that MSCI membership increases the equity ownership of foreign in-

TABLE 4
Instrumental Variable Approach

Table 4 presents the 2-stage least squares (2SLS) regressions of firm innovation on foreign institutional ownership. The instrumental variable for foreign institutional ownership (MSCI) is the time-varying membership in the Morgan Stanley Capital International (MSCI) All Country World Index. All explanatory variables are lagged by 1 year and defined as in Appendix B. Standard errors are clustered at the firm level and reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	1SLS	2SLS		1SLS	2SLS	
	FIO	ln(PATENT)	ln(CITEPAT)	FIO	ln(PATENT)	ln(CITEPAT)
Variables	1	2	3	4	5	6
MSCI	4.331***			2.141***		
	(0.314)			(0.130)		
$FIO_{PREDICTED}$		0.076***	0.084***		0.037***	0.046***
		(0.022)	(0.024)		(0.009)	(0.013)
DIO	0.107***	−0.019***	−0.025***	0.016***	−0.001	−0.001
	(0.023)	(0.005)	(0.005)	(0.005)	(0.001)	(0.002)
INSIDE	−4.275***	0.570***	0.667***	−2.125***	0.096**	0.159***
	(0.354)	(0.127)	(0.142)	(0.188)	(0.047)	(0.057)
ln(AGE)	−0.452***	0.097***	0.102**	−0.709***	0.110***	0.135***
	(0.149)	(0.036)	(0.040)	(0.165)	(0.023)	(0.033)
HHI	0.099	0.270	0.258	2.112*	−0.258	0.084
	(1.438)	(0.350)	(0.391)	(1.157)	(0.162)	(0.229)
HHI^2	0.198	−0.257	−0.257	−1.588	0.213	0.097
	(1.479)	(0.334)	(0.372)	(1.023)	(0.143)	(0.202)
RD	3.233*	1.819***	2.137***	−2.139**	0.149	−0.160
	(1.927)	(0.353)	(0.403)	(0.873)	(0.123)	(0.174)
CAPEX	3.861***	1.708***	2.238***	2.414***	0.274**	0.443***
	(1.408)	(0.345)	(0.390)	(0.739)	(0.105)	(0.149)
PPE	0.781	−0.332**	−0.304*	0.353	−0.090	−0.101
	(0.710)	(0.151)	(0.168)	(0.454)	(0.063)	(0.089)
LEV	−4.076***	−0.191	−0.170	−2.264***	−0.033	−0.110*
	(0.495)	(0.150)	(0.164)	(0.185)	(0.047)	(0.067)
ROA	0.438	−0.467**	−0.683***	−1.180**	0.016	−0.129
	(0.904)	(0.181)	(0.206)	(0.475)	(0.067)	(0.095)
FSALE	2.674**	−0.223*	−0.236*	0.193*	−0.009	−0.016
	(1.047)	(0.118)	(0.121)	(0.115)	(0.016)	(0.023)
ln(SALE)	1.402***	0.037***	0.049***	1.318***	0.050***	0.070***
	(0.092)	(0.012)	(0.016)	(0.044)	(0.016)	(0.023)
TOBINS_Q	0.576***	0.022	0.005	0.211***	0.007	0.009
	(0.078)	(0.021)	(0.024)	(0.031)	(0.005)	(0.007)
KZ	−0.009***	−0.002**	−0.002*	−0.005***	−0.001**	−0.001***
	(0.004)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
P_INDEX	0.378	0.160**	0.237***	0.291**	0.121***	0.156***
	(0.329)	(0.063)	(0.079)	(0.136)	(0.031)	(0.044)
RULE	0.492	0.026	0.029	−0.083	−0.015	−0.068
	(0.660)	(0.118)	(0.139)	(0.241)	(0.055)	(0.078)
GOODGOV	−2.315***	0.431***	0.456***	−0.306*	0.194***	0.182***
	(0.471)	(0.096)	(0.111)	(0.161)	(0.039)	(0.055)
EXPORT	7.363*	−0.732	−1.038	5.806***	−0.504	−0.489
	(4.132)	(0.710)	(0.820)	(1.244)	(0.391)	(0.425)
IMPORT	−8.516**	2.047***	1.854**	−6.556***	1.419***	0.972**
	(4.206)	(0.732)	(0.853)	(1.403)	(0.345)	(0.488)
EQUITY	−0.281	0.115**	0.053	−0.138	0.098***	0.074**
	(0.370)	(0.058)	(0.068)	(0.172)	(0.024)	(0.034)
CREDIT	−0.308***	0.019	−0.007	−0.390***	0.031***	0.008
	(0.098)	(0.020)	(0.023)	(0.074)	(0.011)	(0.015)
ln(GDP)	1.091**	0.128	0.036	0.892**	0.105**	0.117*
	(0.530)	(0.101)	(0.122)	(0.305)	(0.043)	(0.060)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	No	No	No
Country fixed effects	Yes	Yes	Yes	No	No	No
F-test (*p*-value)	<0.001			<0.001		
R^2	0.391	0.213	0.155	0.138	0.065	0.053
No. of obs.	30,008	30,008	30,008	30,008	30,008	30,008

V. Possible Economic Mechanisms

In this section, we explore three possible underlying economic mechanisms through which foreign institutional investors promote firm innovation. Although we attempt to identify different economic mechanisms that underlie the positive effect of foreign institutional ownership on innovation, we acknowledge that these underlying mechanisms are not necessarily mutually exclusive and, if anything, may jointly contribute to the positive effect of foreign institutions on innovation.

A. Monitoring

Due to agency problems caused by the separation of ownership and control, a potential moral-hazard problem emerges in which firm managers overinvest in routine tasks that are less challenging to enjoy private benefits (Hart (1983), Bertrand and Mullainathan (2003)). The theory of Stein (1988) shows that managers could underinvest in innovative projects because of their high-risk nature and inability to generate predictable returns in the short run.

Monitoring by institutional investors is thus an important governance mechanism to mitigate managerial myopia. Compared with small investors who are relatively less informed, institutional investors are better able to provide effective and active monitoring due to their large ownership stakes in firms, as well as their ability to exploit the economy of scale in information production and processing (e.g., Shleifer and Vishny (1986), Grossman and Hart (1988), and Gillan and Starks (2000), (2003)). However, not all institutions are actively engaged in monitoring. For instance, Bushee (1998) finds that institutional investors with short-term investments induce managerial myopia, whereas institutions with long-term investments reduce managers' myopic behavior. Chen et al. (2007) show that long-term institutions focus more on monitoring and influencing efforts than on trading. They also find that independent institutions are more inclined to gather information and get actively involved in the corporate decisions of firms in which they invest, whereas gray institutions are more likely to hold shares without intervening in firms' business.[20]

We thus postulate that if monitoring by foreign institutional investors contributes to increases in firm innovation, then those foreign institutions that have strong incentives to monitor, that is, independent or long-term foreign institutions, should play a more significant role in promoting firm innovation. As such, we separate foreign institutional ownership into 2 components: ownership by independent (or long-term) foreign institutional investors and by gray (or short-term) foreign institutional investors. We then examine the effects of these types of foreign institutions on firm innovation.

Similar to our main analysis, we use OLS regressions with firm fixed effects and the DID analysis to test our conjecture. We present the results in Table 5. In Panel A, we reestimate the baseline OLS regressions but distinguish between independent and gray institutions, as well as long-term and short-term institutions. Columns 1 and 3 focus on 2 key independent variables: the percentage of shares held by independent institutions ($FIO_{INDEPENDENT}$), such as mutual funds

[20]Chen et al. (2007) define mutual fund managers and investment advisors as "independent" institutions and bank trusts, insurance companies, pension funds, and endowments as "gray" institutions.

TABLE 5
Economic Mechanisms: Monitoring

Table 5 presents the results on how the monitoring channel explains the effect of foreign institutional ownership on firm innovation. Panel A presents the regressions with firm fixed effects. Foreign institutional ownership is classified into independent and gray foreign institutional ownership (models 1 and 3) or into long-term and short-term foreign institutional ownership (models 2 and 4). All explanatory variables are lagged by 1 year and defined as in Appendix B. Standard errors are clustered at the firm level and reported in parentheses. Panel B reports the DID estimates. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Firm Fixed Effects

	ln(PATENT)		ln(CITEPAT)	
	X = INDEPENDENT	X = LONG_TERM	X = INDEPENDENT	X = LONG_TERM
Variables	1	2	3	4
FIO_X	0.008**	0.008***	0.011***	0.011***
	(0.003)	(0.003)	(0.004)	(0.004)
$FIO_{EXCLUDING\_X}$	−0.004	0.005	0.002	0.000
	(0.012)	(0.004)	(0.015)	(0.008)
DIO	−0.001	−0.001	−0.000	−0.001
	(0.001)	(0.001)	(0.002)	(0.002)
INSIDE	0.062*	0.062*	0.084*	0.084*
	(0.032)	(0.032)	(0.044)	(0.044)
ln(AGE)	0.085**	0.087**	0.117**	0.118**
	(0.037)	(0.037)	(0.048)	(0.049)
HHI	−0.168	−0.171	0.153	0.152
	(0.274)	(0.274)	(0.347)	(0.347)
HHI^2	0.150	0.152	0.048	0.049
	(0.241)	(0.241)	(0.290)	(0.290)
RD	0.054	0.056	−0.231	−0.233
	(0.132)	(0.132)	(0.215)	(0.215)
CAPEX	0.379***	0.375***	0.519***	0.519***
	(0.134)	(0.134)	(0.184)	(0.184)
PPE	−0.082	−0.083	−0.095	−0.096
	(0.086)	(0.086)	(0.114)	(0.114)
LEV	−0.134**	−0.131**	−0.185***	−0.185***
	(0.057)	(0.057)	(0.070)	(0.071)
ROA	−0.038	−0.035	−0.170	−0.168
	(0.079)	(0.079)	(0.109)	(0.109)
FSALE	0.000	0.000	−0.009	−0.009
	(0.020)	(0.020)	(0.018)	(0.018)
ln(SALE)	0.111***	0.109***	0.115***	0.115***
	(0.015)	(0.015)	(0.020)	(0.020)
TOBINS_Q	0.005	0.005	0.001	0.001
	(0.005)	(0.005)	(0.008)	(0.008)
KZ	−0.001***	−0.001***	−0.001***	−0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
P_INDEX	0.116***	0.116***	0.150**	0.150**
	(0.045)	(0.045)	(0.062)	(0.062)
RULE	−0.032	−0.033	−0.081	−0.081
	(0.071)	(0.071)	(0.093)	(0.093)
GOODGOV	0.130***	0.132***	0.131**	0.131**
	(0.049)	(0.049)	(0.062)	(0.062)
EXPORT	−0.019	−0.030	−0.119	−0.118
	(0.382)	(0.383)	(0.464)	(0.465)
IMPORT	0.786*	0.794*	0.485	0.482
	(0.405)	(0.406)	(0.517)	(0.517)
EQUITY	0.089***	0.089***	0.067*	0.067*
	(0.028)	(0.028)	(0.036)	(0.036)
CREDIT	0.014	0.014	−0.005	−0.006
	(0.011)	(0.011)	(0.015)	(0.015)
ln(GDP)	0.150**	0.152**	0.103	0.104
	(0.066)	(0.066)	(0.086)	(0.086)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Adj. R^2	0.872	0.872	0.799	0.799
No. of obs.	30,008	30,008	30,008	30,008

(continued on next page)

extent, exogenous changes in equity ownership for each type of U.S. foreign institution following the passage of JGTRRA.

After conducting the matching procedure for each type of U.S. foreign institution, we compute the DID estimators for innovation variables in the same way as in Section IV.A. We find that the DID estimates for independent or long-term U.S. foreign institutions are positive and significant at the 1% or 5% levels, whereas the DID estimates for gray or short-term U.S. foreign institutions are largely insignificant. These results once again suggest that the positive effect of foreign institutional ownership on firm innovation is primarily driven by independent or long-term foreign institutions.

Overall, this subsection shows that independent or long-term foreign institutional investors who actively monitor firms play a crucial role in motivating innovation. This evidence suggests that intensive monitoring by foreign institutional investors appears to be a possible underlying mechanism through which foreign institutional investors enhance firm innovation.

B. Insurance

Economics and psychology literature on motivating innovation has shown that although the standard pay-for-performance incentive scheme has positive effects on motivating effort in routine tasks, it may actually undermine performance in tasks that require creativity and exploration (Glucksberg (1962), Manso (2011)). Incentive schemes that motivate innovation must exhibit substantial tolerance for failure, implying that compensation schemes that are less sensitive to performance can, to some extent, be better motivators of innovation (Holmstrom (1989), Ederer and Manso (2013)).

Aghion et al. (2013) find 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 reputational concerns against failure risks arising from their intensive innovation activities. In an experimental study, Ederer and Manso (2013) show that a manager's incentive to innovate is undermined by the threat of contractual termination. Based on these studies, we argue that if foreign institutional investors promote innovation by insulating managers from punishment for innovation failures, CEO turnover and compensation should be less sensitive to performance in the presence of foreign institutional investors.

To test this conjecture, we collect CEO turnover data from the BoardEx database and match them with our sample firms for the period from 2000 to 2010. We are able to match 167 CEO turnover events in our sample firms and end up with 755 firm-year observations in the matched sample. Similarly, we collect CEO compensation data from BoardEx and match them with our sample firms. The resulting matched sample contains 785 firm-year observations.

To test the effect of foreign institutional ownership on the CEO turnover–performance sensitivity, we follow Aghion et al. (2013) and estimate the following linear probability model:

$$(3)\quad \text{CEO\_TURN}_{it} = \alpha + \beta_1 \Delta\text{ROA}_{it-1} + \beta_2 \text{FIO}_{it-1} \times \Delta\text{ROA}_{it-1} + \beta_3 \text{DIO}_{it-1} \times \Delta\text{ROA}_{it-1} + \beta_4 \text{FIO}_{it-1} + \beta_5 \text{DIO}_{it-1} + \beta_6 \ln(\text{MCAP})_{it-1} + \phi_i + \varphi_t + \varepsilon_{it},$$

where i and t refer to firm and year, respectively. CEO_TURN is a dummy variable that equals 1 if the CEO leaves firm i during year t, and 0 otherwise. ΔROA is the change in profitability in percentage points. ln(MCAP) is the natural logarithm of market capitalization. The specification includes firm fixed effects (ϕ) and year fixed effects (φ).

To examine the effect of institutional ownership on pay-for-performance sensitivity, we follow Hartzell and Starks (2003) and estimate the following model:

$$(4) \quad \Delta\text{CEO\_CASH (TOTAL)}_{it} = \alpha + \beta_1 \Delta\text{WEALTH}_{it-1} + \beta_2 \text{FIO}_{it-1} \times \Delta\text{WEALTH}_{it-1} + \beta_3 \text{DIO}_{it-1} \times \Delta\text{WEALTH}_{it-1} + \beta_4 \text{FIO}_{it-1} + \beta_5 \text{DIO}_{it-1} + \beta_6 \ln(\text{MCAP})_{it-1} + \phi_i + \varphi_t + \varepsilon_{it},$$

where i and t refer to firm and year, respectively. ΔCEO_CASH (TOTAL) is the change in the level of cash and bonus compensation (total compensation, which includes cash, bonus, equity, option, and long-term incentive plans). ΔWEALTH is the change in market value from period $t-1$ to t. The specification includes firm fixed effects (ϕ) and year fixed effects (φ).

To address the endogeneity concern, we first estimate regressions with firm fixed effects to absorb time-invariant unobservable firm characteristics. Panel A of Table 6 reports the results estimating equations (3) and (4). Model 1 presents the results estimating equation (3). Consistent with the previous literature, we observe that 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 on ΔROA (−0.011). More importantly, the coefficient estimate on the interaction term, FIO × ΔROA, is positive and significant at the 5% level (0.001), which suggests that the negative effect of performance on CEO turnover is mitigated by foreign institutional ownership. In other words, in firms with greater foreign institutional ownership, CEO performance–turnover sensitivity is lower. In terms of economic significance, an increase in foreign institutional ownership from the 25th percentile to the 75th percentile of its distribution leads to a decrease in the sensitivity of CEO turnover to firm performance from 1.1% to 0.54%.[21]

Models 2 and 3 of Table 6 examine how foreign institutional ownership affects the CEO's pay-for-performance sensitivity. The dependent variable is the change in cash and bonus compensation (model 2) or the change in total compensation (model 3). Consistent with Hartzell and Starks (2003), the coefficient estimates on ΔWEALTH are positive and significant, suggesting that changes in shareholder wealth are positively related to changes in CEO compensation. More importantly, the coefficient estimates on the interaction term, FIO × ΔWEALTH, are negative and significant at the 5% level in both specifications, suggesting that greater foreign institutional ownership largely weakens the CEO's pay-for-performance sensitivity.

[21] We have both FIO and ΔROA measured in percentage points, and the sensitivity of CEO turnover to performance is $\partial\text{Pr(CEO\_TURN)}/\partial\Delta\text{ROA} = -0.011 + 0.001 \times \text{FIO}$, where -0.011 and 0.001 are the coefficient estimates on ΔROA and FIO × ΔROA, respectively. An increase in foreign institutional ownership from the 25th percentile (FIO = 0) to the 75th percentile (FIO = 5.585) of its distribution is associated with a decrease in the sensitivity of CEO turnover to performance from 1.1% $[(-0.011 + 0.001 \times 0) \times 100 = -1.1\%]$ to 0.54% $[(-0.011 + 0.001 \times 5.585) \times 100 \cong -0.54\%]$.

TABLE 6
Economic Mechanisms: Insurance

Table 6 presents the results on how the insurance channel explains the effect of foreign institutional ownership on firm innovation. Panel A reports the regression results with firm fixed effects. In model 1, the dependent variable is a dummy variable (CEO_TURN), which equals 1 if the CEO at the end of the fiscal year is different from the CEO at the end of the previous fiscal year, and 0 otherwise. The main independent variable is the interaction between the change in profitability and foreign institutional ownership (FIO × ΔROA). Models 2 and 3 show the results of regressions of the change in the managers' compensation on foreign institutional ownership, where the dependent variables are measured by the change in cash and bonus compensation (model 2) and the change in total compensation (model 3). The main independent variable is the interaction between the change in shareholders' wealth and foreign institutional ownership (FIO × ΔWEALTH). Panel B report the DID test results. All explanatory variables are lagged by 1 year. Variable definitions are in Appendix B. Standard errors clustered at the firm level (Panel A) and bootstrapped and clustered at the firm level (Panel B) are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Variables	CEO_TURN 1	ΔCEO_CASH 2	ΔCEO_TOTAL 3
Panel A. Firm Fixed Effects			
FIO × ΔROA	0.001** (0.000)		
DIO × ΔROA	0.000 (0.000)		
ΔROA	−0.011** (0.005)		
FIO × ΔWEALTH		−0.018** (0.007)	−0.027** (0.012)
DIO × ΔWEALTH		0.002 (0.005)	0.003 (0.009)
ΔWEALTH		0.382** (0.175)	0.458*** (0.176)
FIO	0.000 (0.006)	15.065* (9.011)	26.776 (33.620)
DIO	0.001 (0.004)	−3.018 (5.688)	−24.286 (19.870)
ln(MCAP)	0.017 (0.036)	−0.007 (0.083)	0.047 (0.083)
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Adj. R^2	0.125	0.227	0.122
No. of obs.	755	785	785
Panel B. Difference-in-Differences Test			
ΔROA × TREAT × POST	0.005*** (0.002)		
ΔROA × TREAT	−0.004** (0.002)		
ΔROA × POST	−0.003*** (0.001)		
ΔROA	−0.006** (0.003)		
ΔWEALTH × TREAT × POST		−0.015* (0.008)	−0.023*** (0.007)
ΔWEALTH × TREAT		−0.007 (0.010)	−0.026 (0.017)
ΔWEALTH × POST		−0.039 (0.085)	−0.012** (0.006)
ΔWEALTH		0.455* (0.263)	0.716*** (0.226)
TREAT × POST	0.028 (0.112)	16.786 (13.156)	−24.132 (15.643)
ln(MCAP)	0.011* (0.006)	0.074 (0.042)	0.017* (0.009)
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Adj. R^2	0.096	0.042	0.078
No. of obs.	110	121	121

Next, we perform a DID analysis and present the results in Panel B of Table 6. Specifically, we match CEO turnover and compensation data from the BoardEx database with the DID analysis sample as constructed in Section IV.A that has 456 treatment firms and 228 control firms. The final samples consist of 110 firm-year observations for the CEO-turnover test and 121 firm-year observations for the CEO-compensation test. To conduct the DID analysis for this mechanism, we estimate the following two models:

$$\text{(5)}\quad \text{CEO\_TURN}_{it} = \alpha + \beta_1 \Delta\text{ROA}_{it-1} \times \text{TREAT}_i \times \text{POST}_t + \beta_2 \Delta\text{ROA}_{it-1} \times \text{TREAT}_i + \beta_3 \Delta\text{ROA}_{it-1} \times \text{POST}_t + \beta_4 \Delta\text{ROA}_{it-1} + \beta_5 \text{TREAT}_i \times \text{POST}_t + \beta_6 \ln(\text{MCAP})_{it-1} + \phi_i + \varphi_t + \varepsilon_{it},$$

$$\text{(6)}\quad \Delta\text{CEO\_CASH (TOTAL)}_{it} = \alpha + \beta_1 \Delta\text{WEALTH}_{it-1} \times \text{TREAT}_i \times \text{POST}_t + \beta_2 \Delta\text{WEALTH}_{it-1} \times \text{TREAT}_i + \beta_3 \Delta\text{WEALTH}_{it-1} \times \text{POST}_t + \beta_4 \Delta\text{WEALTH}_{it-1} + \beta_5 \text{TREAT}_i \times \text{POST}_t + \beta_6 \ln(\text{MCAP})_{it-1} + \phi_i + \varphi_t + \varepsilon_{it},$$

where i and t refer to firm and year, respectively. CEO_TURN, ΔROA, ΔCEO_CASH (TOTAL), ΔWEALTH, TREAT, POST, and ln(MCAP) are defined the same way as in equations (3) and (4). The specification includes firm fixed effects (ϕ) and year fixed effects (φ). Robust standard errors are clustered at the firm level and bootstrapped with 1,000 replications.

Panel B of Table 6 reports the results estimating equations (5) and (6). Model 1 presents the results estimating equation (5). We find that the coefficient estimate on the triple-interaction term, ΔROA × TREAT × POST, is positive and significant at the 5% level. These results suggest that the negative effect of performance on CEO turnover is mitigated more for treatment firms than for control firms following the passage of JGTRRA. Models 2 and 3 present the results estimating equation (6). The coefficient estimates on the triple-interaction term, ΔWEALTH × TREAT × POST, are negative and significant at the 10% and the 1% levels in models 2 and 3, respectively. These results suggest that treatment firms' pay-for-performance sensitivity becomes weaker than that of control firms after the passage of JGTRRA.

Overall, in this subsection, we show that the sensitivities of CEO turnover and compensation to firm performance are weakened in the presence of foreign institutional investors. This finding is consistent with the argument that by providing insurance to managers with career and reputational concerns, foreign institutional investors allow managers to focus more on long-term, risky investments in innovative projects and hence positively contribute to their investee firms' innovation output.

C. Knowledge Spillovers

In this subsection, we explore a third possible mechanism through which foreign institutions contribute positively to firm innovation. In addition to monitoring and insurance, foreign institutions could enhance innovation through facilitating knowledge spillovers in their cross-border investment activities. Compared with domestic institutional investors, this mechanism is unique to foreign institutional investors.

Investment in knowledge creation by one party facilitates innovation by others (Jaffe et al. (2000)). Knowledge spillovers could be indirect and involve different types of stakeholders, including firms, investors, customers, suppliers, competitors, and governments. The literature has suggested that the locus of innovation and knowledge circulation lies in dynamic, competency-based business networks (Voss (2003), Walters and Buchanan (2001), and Wright and Burns (1998)). One example is that CEO network connections facilitate corporate innovation (Faleye, Kovacs, and Venkateswaran (2014)). In this regard, there is anecdotal evidence suggesting that foreign institutional investors could facilitate networks among different stakeholders. For example, Laurence Fink, the CEO of BlackRock, a leading U.S. investment management company with investments in over 100 countries and offices in 30 countries, including India, offered to host a global investors meeting in India in early 2015 in response to the call for investment by the prime minister of India, Narendra Modi, during his visit to the United States in 2014.[22] This example suggests that foreign institutions could facilitate knowledge spillovers through business networks by acting as a bridge between local firms and foreign firms or investors so that they can exchange opportunities and knowledge, which then could contribute to innovation.

Knowledge spillovers can also occur within a multinational corporation. In a study of cross-border mergers and acquisitions, Ferreira et al. (2010) find that foreign institutional investors are a driving force behind cross-border mergers and acquisitions because they act as facilitators, build bridges between firms, and reduce transaction costs and information asymmetry between bidders and target acquisitions. Relatedly, Guadalupe et al. (2012) find that after being acquired by foreign acquirers, domestic firms are likely to innovate through their access to foreign technologies and widening foreign markets. Based on these two studies, a reasonable argument is that foreign institutional investors could contribute to the innovation of domestic firms through facilitating cross-border mergers and acquisitions and, ultimately, knowledge spillovers.

Along these lines, we argue that one possible channel through which foreign institutional investors promote innovation is that they facilitate knowledge spillovers from a more innovative economy to a less innovative economy. They can do so by acting as a facilitator in cross-border mergers and acquisitions or as a bridge for a network of managers, investors, and other stakeholders of foreign and domestic firms to exchange knowledge, ideas, and opportunities, which, to a certain extent, contributes to investee firms' innovation. If our conjecture is supported, the innovativeness of institutional investors' home countries should play a role in firm innovation. In particular, foreign institutional investors from economies with a higher level of innovation output may affect investee firms' innovation output to a larger extent than those from economies with a lower level of

[22]http://www.dnaindia.com/india/report-after-meeting-pm-narendra-modi-blackrock-ceo-offers-to-host-global-investors-meet-in-india-in-2015-2022468.

innovation output because the former can provide better advice and/or have better expertise on how to speed up knowledge transfers.

We test this hypothesis using a data set of country-level patents collected from the World Bank database.[23] We construct 4 measures of country-level innovativeness for each of the 73 countries in which the institutions in our sample are domiciled. The first measure is the total number of patents applied for by all residents of a country in a year scaled by its GDP (PATENT_GDP). The second measure is the total number of patents applied for by all residents of a country in a year scaled by its total population (PATENT_POP). The third measure is the total number of patents applied for 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 patents applied for by all residents of a country in a year scaled by its market capitalization (PATENT_MCAP). We then take the average of each of these country-level innovativeness measures over the 2000–2010 period. We define an institution's home country as a high-innovation (low-innovation) country if the country's innovation measure is above (below) the median of all 73 countries' measures. We then classify foreign institutional ownership according to whether the institutional investors come from high-innovation countries or low-innovation countries and examine the effects of these ownership components on firm innovation.

We run OLS regressions with firm fixed effects to mitigate the endogeneity concern. We reestimate the baseline regressions but distinguish between the ownership of foreign institutional investors from high-innovation countries (FIO_{HIGH_INNO}) and the ownership of foreign institutional investors from low-innovation countries (FIO_{LOW_INNO}). Panel A of Table 7 presents these regression results, based on the innovativeness of foreign institutional investors' home countries, in which the dependent variables are ln(PATENT) (models 1–4) and ln(CITEPAT) (models 5–8). The results show that the coefficient estimates on FIO_{HIGH_INNO} are positive and significant in almost all models except for model 4. The coefficient estimates on FIO_{LOW_INNO} are insignificant in all specifications. These results suggest that the positive effect of foreign institutional ownership on firm innovation is largely driven by institutions from high-innovation foreign countries.

However, it is plausible that the innovativeness of institutional investors' home countries might be correlated with their institutional environments. To address this concern, we include country-level governance of foreign institutions, measured by the anti-self-dealing index of La Porta, Lopez-de-Silanes, and Shleifer (2006), in our analysis. Specifically, we classify foreign institutional investors into 4 groups according to whether a foreign institution comes from a high-innovation (low-innovation) or high-governance (low-governance) country. An institution's home country is defined as a high- or low-governance country if its anti-self-dealing index is above or below the median of all domiciled countries of the sample institutional investors. We classify foreign institutions into 4 groups:

[23]Although the DWPI database contains patent information at the assignee level, it does not have detailed information on the resident country of assignees. The World Bank patent database provides aggregate country-level data on both resident and nonresident patent holders.

TABLE 7

Economic Mechanisms: Knowledge Spillovers

Table 7 reports the results on how the knowledge-spillover channel explains the effect of foreign institutional ownership on firm innovation. A country-level measure of innovativeness is constructed based on 4 ratios: the total number of patents applied for by all residents of a country in a year scaled by i) GDP (PATENT_GDP), ii) total population (PATENT_POP), iii) total number of listed firms (PATENT_FIRMS), and iv) country market capitalization (PATENT_MCAP) measured in that year. A country-level measure of governance is based on the anti-self-dealing index of La Porta et al. (2006). An institution's home country is a high- or low-innovation (governance) country if its measure of innovativeness (governance) is above or below the median of all domiciled countries of sample institutional investors. In Panel A, foreign institutional ownership is classified into ownership from high-innovation countries (FIO_{HIGH_INNO}) and ownership from low-innovation countries (FIO_{LOW_INNO}). In Panel B, foreign institutional ownership is classified into ownership from high-innovation and high-governance countries ($FIO_{HIGHINNO\_HIGHGOV}$), high-innovation and low-governance countries ($FIO_{HIGHINNO\_LOWGOV}$), low-innovation and high-governance countries ($FIO_{LOWINNO\_HIGHGOV}$), and low-innovation and low-governance countries ($FIO_{LOWINNO\_LOWGOV}$). All explanatory variables are lagged by 1 year. Variable definitions are in Appendix B. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	ln(PATENT)				ln(CITEPAT)			
	PATENT_GDP	PATENT_POP	PATENT_FIRMS	PATENT_MCAP	PATENT_GDP	PATENT_POP	PATENT_FIRMS	PATENT_MCAP
Variables	1	2	3	4	5	6	7	8
Panel A. Foreign Institutional Ownership Classified by Foreign Institutions' Home-Country Innovativeness								
FIO_{HIGH_INNO}	0.007*	0.009***	0.009**	0.011	0.011**	0.012***	0.013**	0.020**
	(0.004)	(0.003)	(0.004)	(0.008)	(0.005)	(0.004)	(0.005)	(0.010)
FIO_{LOW_INNO}	0.014	0.001	0.014	0.006	0.018	0.015	0.015	0.007
	(0.009)	(0.025)	(0.012)	(0.004)	(0.011)	(0.033)	(0.015)	(0.005)
DIO	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
INSIDE	0.062*	0.061*	0.061*	0.062*	0.086*	0.084*	0.085*	0.086*
	(0.032)	(0.032)	(0.032)	(0.032)	(0.044)	(0.044)	(0.044)	(0.044)
ln(AGE)	0.087**	0.087**	0.086**	0.087**	0.119**	0.118**	0.118**	0.120**
	(0.037)	(0.038)	(0.038)	(0.038)	(0.049)	(0.049)	(0.049)	(0.049)
HHI	−0.169	−0.171	−0.169	−0.171	0.152	0.151	0.152	0.151
	(0.274)	(0.274)	(0.274)	(0.274)	(0.346)	(0.347)	(0.347)	(0.347)
HHI^2	0.149	0.151	0.150	0.151	0.046	0.049	0.048	0.048
	(0.241)	(0.241)	(0.241)	(0.241)	(0.290)	(0.290)	(0.290)	(0.291)
RD	0.053	0.055	0.055	0.054	−0.233	−0.231	−0.230	−0.231
	(0.132)	(0.132)	(0.132)	(0.132)	(0.215)	(0.215)	(0.215)	(0.215)
CAPEX	0.378***	0.378***	0.377***	0.378***	0.517***	0.519***	0.518***	0.518***
	(0.134)	(0.134)	(0.134)	(0.134)	(0.184)	(0.184)	(0.184)	(0.184)
PPE	−0.080	−0.083	−0.082	−0.081	−0.093	−0.095	−0.095	−0.093
	(0.086)	(0.086)	(0.086)	(0.086)	(0.114)	(0.114)	(0.114)	(0.114)
LEV	−0.133**	−0.133**	−0.132**	−0.134**	−0.184***	−0.185***	−0.185***	−0.185***
	(0.057)	(0.057)	(0.057)	(0.058)	(0.071)	(0.071)	(0.071)	(0.071)
ROA	−0.039	−0.037	−0.039	−0.040	−0.170	−0.170	−0.170	−0.171
	(0.079)	(0.079)	(0.079)	(0.079)	(0.108)	(0.108)	(0.108)	(0.108)
FSALE	0.001	0.000	0.001	0.000	−0.009	−0.009	−0.009	−0.009
	(0.019)	(0.020)	(0.020)	(0.020)	(0.018)	(0.018)	(0.018)	(0.018)
ln(SALE)	0.110***	0.110***	0.110***	0.110***	0.114***	0.115***	0.114***	0.115***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.020)	(0.020)	(0.020)	(0.020)
TOBINS_Q	0.005	0.005	0.005	0.005	0.001	0.001	0.001	0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)	(0.008)	(0.008)	(0.008)
KZ	−0.001***	−0.001***	−0.001***	−0.001***	−0.001***	−0.001***	−0.001***	−0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P_INDEX	0.114**	0.117***	0.115***	0.115***	0.148**	0.151**	0.150**	0.150**
	(0.044)	(0.044)	(0.044)	(0.044)	(0.062)	(0.061)	(0.061)	(0.062)
RULE	−0.033	−0.031	−0.031	−0.033	−0.081	−0.080	−0.078	−0.081
	(0.071)	(0.071)	(0.071)	(0.071)	(0.093)	(0.093)	(0.093)	(0.093)

(continued on next page)

TABLE 7 (continued)
Economic Mechanisms: Knowledge Spillovers

	ln(PATENT)				ln(CITEPAT)			
	PATENT_GDP	PATENT_POP	PATENT_FIRMS	PATENT_MCAP	PATENT_GDP	PATENT_POP	PATENT_FIRMS	PATENT_MCAP
Variables	1	2	3	4	5	6	7	8
Panel A. Foreign Institutional Ownership Classified by Foreign Institutions' Home-Country Innovativeness (continued)								
GOODGOV	0.134***	0.130***	0.131***	0.133***	0.133**	0.130**	0.129**	0.131**
	(0.049)	(0.049)	(0.049)	(0.049)	(0.062)	(0.062)	(0.062)	(0.062)
EXPORT	−0.043	−0.029	−0.042	−0.039	−0.142	−0.123	−0.137	−0.136
	(0.383)	(0.383)	(0.384)	(0.383)	(0.464)	(0.465)	(0.465)	(0.465)
IMPORT	0.803**	0.792*	0.803**	0.802**	0.501	0.486	0.497	0.500
	(0.406)	(0.406)	(0.406)	(0.406)	(0.517)	(0.517)	(0.518)	(0.518)
EQUITY	0.091***	0.089***	0.090***	0.090***	0.069*	0.067*	0.068*	0.068*
	(0.028)	(0.028)	(0.028)	(0.028)	(0.036)	(0.036)	(0.036)	(0.036)
CREDIT	0.014	0.014	0.014	0.014	−0.005	−0.006	−0.005	−0.005
	(0.011)	(0.011)	(0.011)	(0.011)	(0.015)	(0.015)	(0.015)	(0.015)
ln(GDP)	0.149**	0.152**	0.150**	0.150**	0.102	0.104	0.104	0.105
	(0.066)	(0.066)	(0.066)	(0.066)	(0.086)	(0.086)	(0.086)	(0.086)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.872	0.872	0.872	0.872	0.799	0.799	0.799	0.799
No. of obs.	30,008	30,008	30,008	30,008	30,008	30,008	30,008	30,008
Panel B. Foreign Institutional Ownership Classified by Foreign Institutions' Home-Country Innovativeness and Governance								
$FIO_{HIGHINNO\_HIGHGOV}$	0.009***	0.007*	0.010**	0.013*	0.011**	0.009*	0.012**	0.018*
	(0.003)	(0.004)	(0.005)	(0.008)	(0.005)	(0.006)	(0.006)	(0.010)
$FIO_{HIGHINNO\_LOWGOV}$	0.004**	0.003*	0.005***	0.004	0.004**	0.004**	0.005***	0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
$FIO_{LOWINNO\_HIGHGOV}$	0.013	0.019	0.011*	0.005*	0.019	0.035	0.011**	0.005*
	(0.009)	(0.012)	(0.006)	(0.003)	(0.012)	(0.025)	(0.005)	(0.003)
$FIO_{LOWINNO\_LOWGOV}$	0.009	0.008	0.005	0.001	0.008	0.006	0.004	0.006
	(0.006)	(0.012)	(0.009)	(0.004)	(0.008)	(0.015)	(0.011)	(0.005)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.872	0.872	0.872	0.872	0.799	0.799	0.799	0.799
No. of obs.	30,008	30,008	30,008	30,008	30,008	30,008	30,008	30,008

high-innovation and high-governance countries ($FIO_{HIGHINNO\_HIGHGOV}$), high-innovation and low-governance countries ($FIO_{HIGHINNO\_LOWGOV}$), low-innovation and high-governance countries ($FIO_{LOWINNO\_HIGHGOV}$), and low-innovation and low-governance countries ($FIO_{LOWINNO\_LOWGOV}$).

In Panel B of Table 7, we find that the coefficient estimates on $FIO_{HIGHINNO\_HIGHGOV}$ are positive and significant, suggesting that foreign institutions from high-innovation and high-governance countries positively influence firm innovation. In addition, the coefficient estimates on $FIO_{HIGHINNO\_LOWGOV}$ remain positive and significant (except for models 4 and 8), which suggests that those foreign institutions from high-innovation but low-governance countries positively affect the innovation of their investee firms. In summary, we find evidence suggesting that foreign institutions coming from high-innovation countries positively affect firm innovation, regardless of their governance level.

To the extent that the United States is the most innovative country in our sample, the DID analysis reported in Panel C of Table 3 also provides evidence that supports this underlying economic mechanism. Specifically, the coefficient estimates on TREAT × POST, which captures the exogenous increase in U.S. foreign institutional ownership following the passage of JGTRRA, are positive and statistically significant at the 1% level, whereas those of $\text{FIO}_{\text{NONUS}}$ are significant only at the marginal level. The magnitudes of these estimates on TREAT × POST are much larger (5 times larger) than those on $\text{FIO}_{\text{NONUS}}$. These results suggest that a positive shock in the foreign equity ownership of institutions coming from a more innovative country (e.g., the United States) leads to a significantly larger increase in the innovation output of investee firms.

Overall, in this subsection, we show that the innovativeness of foreign institutional investors' home countries positively contributes to investee firms' innovation output, which suggests that innovation travels with foreign institutions that come from high-innovation countries. Hence, knowledge spillovers are a plausible mechanism through which foreign institutional investors promote innovation.[24]

VI. Conclusion

We examine the effect of foreign institutional investors on firm innovation. Using firm-level data across 26 non-U.S. economies for the 2000–2010 period, we document a positive effect of foreign institutional ownership on firm innovation. To address endogeneity concerns, we use both an IV approach and a DID approach that relies on a plausibly exogenous variation in foreign institutional ownership generated by a quasi-natural experiment, the passage of JGTRRA. Our identification tests suggest that this positive effect is causal.

We further explore three possible underlying economic mechanisms through which foreign institutional investors promote innovation. We find that foreign institutions promote firm innovation by acting as active monitors, by providing insurance against innovation failures to firm managers with career or reputational concerns, and by promoting knowledge spillovers from high-innovation countries. Our article provides the first rigorous empirical study to examine the role of foreign institutional investors in motivating technological innovation outside the United States.

[24]It is reasonable to argue that foreign institutional ownership affects firm innovation over a long-term period, and how fast this effect takes place should depend on the underlying economic mechanisms. We thus extend our analysis by using 2- or 3-year-ahead, instead of 1-year-ahead, innovation measures as the dependent variables in the baseline regression, as well as in regressions that explore the underlying economic mechanisms. Under the monitoring mechanism, it appears that foreign institutional investors have more immediate effects on firm innovation, because the coefficient estimates on $\text{FIO}_{\text{INDEPENDENT}}$ and $\text{FIO}_{\text{LONG\_TERM}}$ become less significant when the 2- or 3-year-ahead innovation measures are used as the dependent variables. Conversely, in the knowledge-spillover mechanism, it apparently takes foreign institutional investors a longer time before they can influence firm innovation; the coefficient estimates on $\text{FIO}_{\text{HIGH\_INNO}}$ remain highly significant when the 2-year-ahead innovation measures are used as the dependent variables. We present these regression results in Table A7 in the Internet Appendix.

Appendix A. Thomson Reuters DWPI Classification System

DWPI categorizes patents using a simple classification for all technologies. Patents are divided into 3 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 is a total of 20 such sections, designated A–M for chemical, P–Q for engineering, and S–X for electronic and electrical engineering, as follows:

Chemical

A. Polymers and Plastics
B. Pharmaceuticals
C. Agricultural Chemicals
D. Food, Detergents, Water Treatment and Biotechnology
E. General Chemicals
F. Textiles and Paper-Making
G. Printing, Coating, Photographic
H. Petroleum
J. Chemical Engineering
K. Nucleonics, Explosives and Protection
L. Refractories, Ceramics, Cement and Electro(in)organics
M. Metallurgy

Engineering

P1. Agriculture, Food, Tobacco
P2. Personal, Domestic
P3. Health, Amusement
P4. Separating, Mixing
P5. Shaping Metal
P6. Shaping Non-metal
P7. Pressing, Printing
P8. Optics, Photography, General
Q1. Vehicles in General
Q2. Special Vehicles
Q3. Conveying, Packaging, Storing
Q4. Buildings, Construction
Q5. Engines, Pumps
Q6. Engineering Elements
Q7. Lighting, Heating

Electronic and Electrical Engineering

S. Instrumentation, Measuring and Testing
T. Computing and Control
U. Semiconductors and Electronic Circuitry
V. Electronic Components
W. Communications
X. Electric Power Engineering

Appendix B. Variable Definitions

1. Innovation Variables (*Source*: Thomson Innovation)

ln(PATENT): Natural logarithm of 1 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(CITEPAT): Natural logarithm of 1 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 (*Source*: FactSet Ownership)

$FIO_{LOWINNO\_LOWGOV}$: Low-innovation and low-governance foreign institutional ownership, defined as the sum of shares owned by all foreign institutions that come from low-innovation and low-governance countries, as a percentage of the firm's total number of shares outstanding.

3. Control Variables (*Source*: Worldscope)

TA: Book value of total assets, measured at the end of the fiscal year in millions.

RD: Research and development expenditures scaled by total assets, measured at the end of the fiscal year; set to 0 if missing.

FSALE: The percentage of foreign sales in total sales.

INSIDE: Number of shares held by insiders as a proportion of the total number of shares outstanding.

ln(SALE): Natural logarithm of net sales.

ln(AGE): Natural logarithm of the number of years since the firm has its listed price.

CAPEX: Capital expenditures divided by total assets, measured at the end of the fiscal year.

PPE: Net property, plant, 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 Kaplan and Zingales (1997) 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)].

TOBINS_Q: Growth opportunities, defined as market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes, scaled by total assets, measured at the end of the fiscal year.

HHI: Herfindahl index of 4-digit Standard Industrial Classification (SIC) industry to which the firm belongs, measured at the end of the fiscal year.

HHI^2: Squared HHI.

4. Country-Level Innovativeness and Control Variables (*Source*: World Bank, World Development Indicators (WDI), and other sources)

PATENT_GDP: Total number of patent applications applied for in a year by all residents of a country divided by GDP.

PATENT_POP: Total number of patent applications applied for in a year by all residents of a country divided by total population.

PATENT_FIRMS: Total number of patent applications applied for in a year by all residents of a country divided by the number of listed firms.

PATENT_MCAP: Total number of patent applications applied for in a year by all residents of a country divided by market capitalization.

P_INDEX: Patent protection index, developed by Ginarte and Park (1997) and updated by Park (2008). The index data are constructed for more than 100 countries, updated every 5 years since 1960. The index takes values between 0 and 5. Higher values indicate patent laws with stronger intellectual property rights. The index coding scheme aggregates information on i) membership in international treaties (Paris Convention, International Convention for the Protection of New Varieties of Plants, Patent Cooperation Treaty, Budapest Treaty, Agreement on Trade-Related Aspects of Intellectual Property Rights), ii) enforcement mechanisms (preliminary injunctions, contributory infringement pleadings, burden-of-proof reversal), iii) restrictions on patent rights (working requirements, compulsory licensing, revocation of patents), iv) duration of protection, and v) extent of coverage (pharmaceuticals, chemicals, food, surgical products, microorganisms, utility models, software, plant and animal varieties).

RULE: The rule-of-law indicator of Kaufmann et al. (2011), which captures perceptions of the extent to which agents have confidence in and abide by the rules of society, in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

GOODGOV: The government effectiveness indicator of Kaufmann et al. (2011), which captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

EXPORT: The ratio of a country's exports to its GDP.

IMPORT: The ratio of a country's imports to its GDP.

EQUITY: The ratio of a country's stock market capitalization to its GDP.

CREDIT: The ratio of a country's bank credit to its GDP.

ln(GDP): The natural logarithm of real GDP per capita.

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