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Institutional stock ownership and firm innovation: Evidence from China☆

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ABSTRACT

This paper investigates different institutions' ability to influence firm innovation in the largest emerging market, China. We show that mutual funds' holdings significantly increase firm innovation, but grey institutional holdings (including insurance companies and pension funds) and Qualified Foreign Institutional Investor (QFII) holdings have less or no significant impact on innovations. We suggest this is due to the high equity holdings and less business connections of mutual funds on (with) portfolio firms in comparison with other institutional investors. Our results are robust after applying different measures of firm innovation and controlling for possible endogeneity. This study sheds new light on the effect of different institutional ownerships on firm innovation in emerging economies. Our results provide further evidence that in comparison with more developed markets, institutional investors in emerging markets can govern invested firms through "threat of exit" even when holding a small proportion of shares in the firms.

1. Introduction

The effects of institutional investors' stock ownership on firm innovation have been widely studied in developed countries (Kochhar and David, 1996; Aghion et al., 2013; Harford et al., 2016), but there is much less research in developing countries. China, the largest emerging market, has enjoyed fast economic growth for the past two decades. While innovation and property right protection have become challenges to its sustainable economic growth, the Chinese government has made significant progress in improving innovation. A report by the National Science Board (NSB), which sets policy for the US government's National Science Foundation, showed that the centre of high-tech gravity was shifting to Asia, and to China particularly, and China's share of the world's high-technology manufacturing increased from eight percent in 2003 to 24% in 2012, in comparison with the number one US share of 27%[1] .

Since 2000, China has made substantial efforts to develop financial institutions, with the intention to improve firm efficiency and governance, and stabilise the financial markets (Firth et al., 2016). Previous studies have documented that

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[1] This information is obtained from the Foreign Policy website http://foreignpolicy.com/2014/02/07/its-official-china-is-becoming-a-new-innovation-powerhouse/.

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mutual funds' holdings in China can improve firm performance (Yuan et al., 2008), can reduce firms' fraudulent activity (Aggarwal et al., 2014) and can influence firms to pay higher cash dividends (Firth et al., 2016). Firth et al. (2016) argue that institutional investors in China could have a more important role in monitoring firms than their counterparts in developed countries due to the strong government control of listed firms, weak enforcement of property rights, and diffused and inexperienced individual investors. This paper provides new support for this argument from a new research angle; that is, the influence of institutional holdings on firm innovation.

There is considerable debate about the effects of institutional investors on firm innovation. Institutional investors are divided into different types; where myopic investors pay attention to short-term benefit and have negative impact on firm innovation (Graves, 1988), while superior investors and active investors can either pick firms with better innovation or actively influence firms to improve innovation (Kochhar and David, 1996). Recent empirical evidence has shown that institutional ownership has a positive impact on firm innovation, especially when the innovation is measured by outputs (such as patents) rather than inputs (such as R&D expenses), and when institutions are pressure-resistant and have less business dealings with portfolio firms such as mutual funds, foreign institutions and long-term institutions (Kochhar and David, 1996; Bena et al., 2016; Harford et al., 2016).

In this paper, we examine the relation between institutional stock holdings and firm innovation in Chinese listed firms during the period from 2001 to 2014, as the data on corporate patents become sufficiently comprehensive since 2001. We distinguish between the effects of mutual funds, grey institutions (including insurance companies and pension funds) and qualified foreign institutional investors (QFIIs), as these three types of institutional investors have different characteristics, including the level of holdings in listed firms, potential business connections with listed firms and the intensity of communications with listed firm (Aggarwal et al., 2011). Recent theories state that institutional investors can influence firms even when they have no intervention power, e.g. institutional investors just hold a small proportion of shares in the invested firms, given those investors tend to be informed traders who could control management through "threat of exit" (Bharath et al., 2013). We expect mutual funds holdings to have a more positive effect on firm innovation than the other types mainly due to two reasons. First, mutual funds have the largest holdings among all institutional investors in China and less business connections with listed firms. Second, mutual funds appear to be more active compared with grey institutions and QFIIs to enhance communication with listed firms through site visits in China. Site visits are becoming an important communication channel between mutual funds and listed firms in Chinese stock markets. According to Liu et al. (2017), the number of companies listed in the Shenzhen Stock Exchange that have been visited by mutual funds increased from 161 in 2007 to 837 in 2014. Liu et al. (2017) document that mutual funds gain information advantage over other investors from face-to-face communication with listed firms, and thereby they are more informed traders compared with others. In addition, mutual funds can deliver the firm-specific information acquired through communication to other investors by trading behaviour. Given face-to-face communication mitigates information asymmetry, investors will be more tolerant to firms' short-term underperformance after the communication, which is critical in motivating firm innovation (Jiang and Yuan, 2018). Jiang and Yuan (2018) find institutional investors' site visits significantly enhance corporate innovation.

We find that mutual fund ownership is positively and significantly associated with firm innovation, measured by patent applications in a firm. However, the impact of grey institutions and QFII holdings on firm innovation is much weaker. We also use the changes of patent applications and approved patents to measure firm innovation and control for innovation inputs (R&D expenses), the results are consistent. To deal with the potential endogeneity issues, we adopt three approaches including lagged values of independent variables in the fixed effect regressions, the two-stage instrumental variable regressions and system generalized method of moments techniques. The results are all consistent.

To the best of our knowledge, this is one of more recent studies focusing on the effects of institutional ownership on firm innovation in China. Our paper examines this relationship in the largest emerging market, with a focus of different types of institutions and different firm innovation measures. This paper contributes to the literature in the following ways. First, it extends previous studies of the developed markets and sheds light on the influence of relatively low institutional stock holdings on firm innovations in a transitional and emerging economy where the level of corporate governance is low. Second, this study distinguishes institutional investors into three different types; mutual funds, grey institutions (including insurance companies and pension funds), and QFIIs. Examining whether different types of institutions lead to observable differences in firm innovation can shed light on heterogeneity in influences across institutional investors. Similar to Chen et al. (2007) and Aggarwal et al. (2014), we find that the monitoring effect of mutual funds is stronger than those of grey institutions or QFIIs. Our results provide further evidence to the proposal that institutional investors can govern invested firms through "threat of exit" even when holding a small proportion of shares in the firms. Third, instead of using innovation inputs (such as capital expenditure or R&D intensity), we use actual outcomes of innovation (patent applications) to measure firm innovation. Researchers have argued that patent counts are the most important measure of a firm's innovation activities (Griliches, 1990), as high R&D intensity does not necessarily lead to high innovation, given the possibility of inefficient management and agency costs (Jensen and Meckling, 1976; Kochhar and David, 1996). Evidence of a positive relationship between patents and firm value has also been found in the US and Europe (Hall et al., 2005, 2007). As patent application is a long-term process[2], we follow Fang et al. (2014) and use the number of patent applications to capture the firm innovation activities. We also

[2] The average time period for patent application in China is one to two years.

examine the influence of the institutional holdings on three sub-categories of patents in China, namely invention patents, utility model patents and design patents.

Section 2 reviews the relevant literature and develops our research question. Section 3 outlines the data and methodology, and details how institutional ownerships are grouped, and proxies for firm innovation and various control variables are constructed. The main results, and the robustness and endogeneity checks are shown in Section 4. Section 5 concludes.

2. Literature review and hypothesis development

Previous studies find that institutional ownership has a direct effect on firm innovation activities (e.g., Hansen and Hill, 1991; Kochhar and David, 1996). As Kochhar and David (1996) summarise, there are three competing hypotheses and three types of institutional investors; myopic investors, superior investors, and active investors. The myopic investor hypothesis argues that institutional investors search for short-term gains. To maintain high stock values and avoid becoming a takeover target, firm managers might be forced to cut back on risky long-term investments, such as expenditure on firm innovations (Hayes and Abernathy, 1980). Myopic investor hypothesis suggests that institutional holding and firm innovation will be negatively related. The superior investor hypothesis implies that institutions are able to better choose firms with higher value potential, defined by greater innovative ability. Finally, the active investor hypothesis suggests that institutions do not necessarily pick firms with higher innovation, but rather use their "voice" to actively influence these portfolio firms to increase innovation and create long-term firm value. Although both the superior and active investor hypotheses suggest that the association between institutional holdings and firm innovation will be positive, the active investor hypothesis implies that institutions which have higher motivation and ability to monitor (such as mutual funds) could impact firm innovation more than others (such as banks and insurance companies).

As for the empirical evidence on the relationship between institutional holdings and firm innovation, Graves (1988) finds a negative relationship between institutional holdings and R&D intensity (measured by firm R&D expenditure), supporting the myopic investor hypothesis. However, Baysinger, et al. (1991) and Hansen and Hill (1991) find a positive relationship between institutional ownership and R&D intensity; while Aghion et al. (2013) find that greater institutional ownership leads to more innovation in US firms by reducing career risks. These results support the superior investor hypothesis. To explain the positive impact of institutional ownership on firm innovation, Cheng, et al. (2015) show that institutional investors, particularly fund managers, can communicate with management teams directly through site visits and use their voting rights during shareholder meetings to influence firms. Other researchers suggest institutional investors can influence firm decisions by the threat of exit (Admati and Pfleiderer, 2009; Edmans and Manso, 2011).

Furthermore, most recent studies support the active investor hypothesis, given the heterogeneity in institutional investors. Chen et al. (2007) and Ferreira and Matos (2008), among others, find that not all institutional investors act as independent institutions whose primary consideration is the value maximisation of the portfolio firms. If an institution has a business relationship with a portfolio firm, the dual activities of investment and business relationships can create a conflict of interest for the institution and reduce the institution's motivation to monitor or influence firm behaviour. Brickley et al. (1988) refer to them as pressure-sensitive institutions, such as banks, insurance companies and nonbank trusts. If institutions do not have business relationship with the firm, but have only an investment relationship, especially a long-term investment relationship, these so-called pressure-resistant institutions are more likely to use their voice over firm management (Brickley et al., 1988). Bena et al. (2016) study 30,000 publicly listed firms in 30 countries from 2001 to 2010 and find foreign institution presence leads to higher innovation productivity. Changing from inputs to outputs, Harford et al. (2016) find that in the US long-term institutional investors promote firm innovation efficiency measured by patent counts, citations originality and generality.

In China, institutional investors have developed very quickly in the last two decades. There are three major types of institutional investors in the Chinese markets, namely mutual funds, grey institutions (including insurance companies and pension funds) and QFIIs. Firth, et al. (2010) state that mutual funds are the largest institutional investors among tradable shareholders and their holdings account for 76% of all the institutional tradable shareholdings in China. So far, evidence has been found that mutual fund stock ownerships have effective monitoring impact on portfolio firms in China, while other institutional investor stock holdings do not have a similar impact.

Using a sample period from 2001 to 2005, Yuan et al. (2008) find evidence to support the regulatory efforts in China to promote mutual funds as a beneficial corporate governance mechanism and to overcome the free-rider problem pronounced among diffused individual investors. Aggarwal et al. (2014) study the period from 2001 to 2011 and find strong evidence that mutual fund ownership is significantly related to less fraudulent activities, and mutual funds are the only type of institutions that can monitor firms and help reduce the incidence of fraud in China. Firth et al. (2016) investigate the empirical relation between institutional ownership and firms' dividend policy in China from 2003 to 2011 and show that mutual fund ownership is able to influence firms to pay cash dividends and to increase cash dividend payments. However, other institutional investors such as banks, insurance companies and securities companies do not appear to have a significant impact on firms' dividend policy, given their business relationships with the portfolio firms.

Given that mutual funds in China have much higher stock holdings than other institutional investors and have less business relations with portfolio firms, we follow the active investor hypothesis and expect mutual funds to have more positive impact on the firm innovation of Chinese firms than on that of grey institutions or QFIIs.

H1. Among different institutions, mutual funds have a more positive impact on the firm innovation of Chinese firms.

3. Research design

3.1. Data collection

The data on institutional ownership and instrument variables are collected from the Resset database. The data on corporate patents and patent applications are obtained from the China Stock Markets and Accounting Research (CSMAR) database, as is the rest of the data. The sample period is from 2001 to 2014, as the data on corporate patents are not complete before 2001. We exclude financial firms to make our sample comparable with other studies. Our sample consists of 7442 firm-year observations during sample period. Furthermore, we winsorize variables defined as ratios at the upper and lower 1% level.

3.2. Variables and empirical tests

When measuring firm innovation, we use actual outcomes of innovation, instead of innovation inputs (such as capital expenditure or R&D intensity). As discussed, high innovation inputs do not necessarily lead to high innovation outputs, given the possibility of inefficient management and agency costs (Jensen and Meckling, 1976; Kochhar and David, 1996, and Sheikh, 2018). As patent application is a long-term process, we follow Fang et al. (2014) and employ the direct firm innovation outputs (patent application numbers) as our main innovation measures. Patent applications represent the latest and most direct innovation outputs, while actual numbers of patents include past innovative outputs. We also examine three sub-categories of patents in China, namely invention patents, utility model patents and design patents. The variables PATENT_APP, INV_APP, UTL_APP, and DES_APP are denoted as the applications of total patents, invention patents, utility model patents and design patents, respectively. In the robustness tests, we also use the changes of patent applications and approved patents to measure firm innovation and control for innovation inputs (R&D expenses) in the fixed effect regressions.

To investigate the effect of different types of institutional investors on the innovation outputs of listed firms, we group institutional investors into three categories; mutual funds, grey institutions, and foreign institutions. As discussed above, studies find that mutual funds have significant monitoring effects on Chinese listed firms in terms of reducing fraud activities and increasing cash dividend payments (Aggarwal et al., 2014; Firth et al., 2016). We group insurance companies and pension funds (including both public and corporate pension funds) as grey institutions, as these types of institutions are more likely to hold shares without reacting to management actions (Aggarwal et al., 2011). Almazan, et al. (2005) also suggest these types of institutions, as “passive” investors. In the early years of Chinese stock market development, foreign investors were not permitted to invest in RMB-denominated A shares in China’s Shanghai and Shenzhen Stock Exchanges. In 2002, aligned with the People’s Bank of China (the de-facto central bank), the China Securities Regulatory Commission (CSRC) introduced the QFII Scheme, which allowed foreign institutional investors who met certain criteria to invest in Chinese A shares. Compared with domestic institutions, foreign institutions are considered to be more sophisticated and as having more experience of investing in stock markets. Huang and Zhu (2015) suggest that QFIIs were likely to perform arm’s-length negotiation and monitoring in Chinese state-controlled firms during the one-off event -the non-tradable share reform. However, the impact of QFII’s on-going monitoring of Chinese listed firms is an empirical question. In this study, the variables of MF, GREY, and QFII are denoted as the percentage of shares held by mutual funds, grey institutional investors, and QFIIs, respectively.

We employ Ordinary Least Square (OLS) regressions to test our hypothesis. Following the methodologies in Aggarwal et al. (2014) and Firth et al. (2016), we investigate the effects of different institutional ownerships on the future firm innovation, by regressing the patent applications on the one-year-lagged values of various institutional holdings and other control variables. Following Fang et al. (2014), we use the logarithm of one plus patent application numbers as the dependent variables, as the patent numbers can be highly skewed. We use industry and year fixed effect models to control for the possible endogeneity caused by unobserved variables. Specifically, for the patent application of firm *i* in year *t*, the regression models are shown as follows:

$$\begin{aligned}\mathrm{Ln}(1+\mathrm{INV\_APP}_{i,t}/\mathrm{UTL\_APP}_{i,t}/\mathrm{DES\_APP}_{i,t}/\mathrm{PATENT\_APP}_{i,t}) &= \alpha_0+\alpha_1\mathrm{MF}_{i,t-1}+\alpha_2\mathrm{GREY}_{i,t-1}+\alpha_3\mathrm{QFII}_{i,t-1}+\alpha_4\mathrm{TOP}_{i,t-1}\\ &+\alpha_5\mathrm{STATE}_{i,t-1}+\alpha_6\mathrm{DUAL}_{i,t-1}+\alpha_7\mathrm{IND}_{i,t-1}+\alpha_8\mathrm{Ln\_BOARD}_{i,t-1}+\alpha_9\mathrm{Ln\_MEETINGS}_{i,t-1}+\alpha_{10}\mathrm{ROA}_{i,t-1}\\ &+\alpha_{11}\mathrm{GROWTH}_{i,t-1}+\alpha_{12}\mathrm{CASH}_{i,t-1}+\alpha_{13}\mathrm{LEV}_{i,t-1}+\alpha_{14}\mathrm{SIZE}_{i,t-1}+\alpha_{15}\mathrm{CHINEXT}_{i,t-1}+\alpha_{16}\mathrm{REGION}_{i,t-1}+\varepsilon \qquad (1)\end{aligned}$$

We control for ownership concentration (TOP) and state control (STATE), which are measured by the percentage of shares held by the largest shareholder and by the government (including the government agents and state-owned enterprises), respectively. The objectives and risk-taking incentives of the largest shareholders and the state are likely to be different from those of institutional investors. Khaw et al. (2016) find that to achieve stable stock returns and reduce the uncertainty of the stock markets, the government tends to take less risky investments. DUAL, IND, BOARD, and MEETINGS are variables that control for the effect of internal governance, which could potentially impact firm innovation. DUAL is a dummy variable,

Table 1
Number of patents during the sample period.

Panel A: Patent applications by year		
Year	Total patent applications	Patent applications per firm
2001	2876	11.50
2002	3893	12.85
2003	5587	13.86
2004	6969	15.28
2005	9950	18.60
2006	14059	20.43
2007	21168	24.79
2008	26489	24.64
2009	35477	27.85
2010	45130	32.24
2011	57305	37.43
2012	67408	43.55
2013	72378	46.46
2014	68671	44.94
Total	437360	
Panel B: Patent applications by industry		
Industry	Total patent applications	Patent applications per firm
Agriculture	1463	18.91
Mining	38178	232.75
Industrial and manufacturing	311123	53.83
Utilities	1824	31.01
Construction	6072	34.24
Transportation	9194	43.28
Information Technology	67976	68.83
Wholesale and retail trade	337	13.58
Real estate	483	17.03
Social Services	552	12.27
Communication and Culture	42	5.83
Conglomerates	116	5.07
Total	437360	
Panel C: Patent numbers by year		
Year	Total patent	Patent per firm
2001	2596	17.38
2002	4051	17.98
2003	6213	21.39
2004	9047	24.87
2005	12261	29.19
2006	15728	34.51
2007	23067	40.50
2008	32544	43.68
2009	45180	51.01
2010	65849	61.58
2011	95608	72.00
2012	141483	90.10
2013	180645	112.11
2014	225161	134.93
Total	859433	
Panel D: Patent numbers by industry		
Industry	Total patent	Patent per firm
Agriculture	1691	18.94
Mining	80314	309.55
Industrial and manufacturing	693749	87.66
Utilities	1318	27.90
Construction	8603	38.19
Transportation	419	15.09
Information Technology	69421	145.85
Wholesale and retail trade	927	17.36
Real estate	1276	23.85
Social Services	1211	21.39
Communication and Culture	351	10.60
Conglomerates	153	13.71
Total	859433	

Table 1 reports the number of patent applications and approved patents by year and industry. The sample period is from 2001 to 2014.

Table 2
Institutional holdings during the sample period.

Year	Type	Mean	Median	Type	Mean	Median	Type	Mean	Median
2001	MF	0.0060	0.0007	QFII	0.0001	0	GREY	0.0001	0
2002	MF	0.0100	0.0024	QFII	0.0001	0	GREY	0.0001	0
2003	MF	0.0084	0.0000	QFII	0.0002	0	GREY	0.0005	0
2004	MF	0.0194	0.0004	QFII	0.0004	0	GREY	0.0012	0
2005	MF	0.0254	0.0004	QFII	0.0013	0	GREY	0.0024	0
2006	MF	0.0342	0.0004	QFII	0.0026	0	GREY	0.0050	0
2007	MF	0.0573	0.0084	QFII	0.0023	0	GREY	0.0033	0
2008	MF	0.0529	0.0059	QFII	0.0015	0	GREY	0.0035	0
2009	MF	0.0607	0.0186	QFII	0.0020	0	GREY	0.0044	0
2010	MF	0.0600	0.0246	QFII	0.0018	0	GREY	0.0074	0
2011	MF	0.0516	0.0162	QFII	0.0013	0	GREY	0.0080	0
2012	MF	0.0430	0.0097	QFII	0.0013	0	GREY	0.0073	0
2013	MF	0.0422	0.0072	QFII	0.0016	0	GREY	0.0066	0
2014	MF	0.0421	0.0183	QFII	0.0016	0	GREY	0.0079	0

This table reports average stock holdings of different types of institutional investors by year during the sample period. MF stands for mutual funds' holdings. QFII stands for stock holdings of QFIIs. GREY stands for stock holdings of grey institutions, including insurance companies, public pension funds and corporate pension funds.

which takes the value of 1 if the board chair also holds the position of CEO, and 0 otherwise. IND is the proportion of independent directors on the board. BOARD is the number of directors on the board. MEETINGS is the number of board meetings held in a year. We use the logarithm of BOARD and MEETINGS in the regression. We also control the effects of the financial status on corporate patents, using ROA, GRWOTH, CASH, and LEV. ROA is the return on total assets. GRWOTH is the sales growth rate. CASH is denoted as the net cash flow from operating activities scaled by total assets. LEV is the ratio of total debt to total assets. Bushee (1998) suggests that firms with higher change in sales, lower leverage and more free cash flow would have more growth opportunities, less potential debt covenant incentives, and more funds available for innovation. SIZE is the logarithm of total assets. CHINEXT is a dummy variable, which takes the value of 1 if a firm is listed on the ChiNext board, and 0 otherwise. ChiNext is a NASDAQ-style board under the Shenzhen Stock Exchange. Most firms listed on the ChiNext are fast-growing and high-tech firms, which may be more innovative. REGION is also a dummy variable, which takes the value of 1 if a listed firm's headquarter is located in more developed regions (i.e., Beijing, Shanghai, Guangdong, Jiangsu, and Zhejiang), and 0 otherwise. We expect that listed firms from developed regions are more innovative. Furthermore, industry fixed effects are included in the regression as firms' innovation activities vary across different industries. The industry classifications are followed by the CSRC guidelines. Year fixed effects are also included in our regressions to control for the possibility that unobserved year-specific attributes may affect corporate innovation activities. All the definitions of variables in this study are shown in the Appendix.

4. Empirical results and robustness tests

Table 1 reports the numbers of patent applications and patents (including invention, utility model, and design patents) of listed firms in each year during the sample period and in each industry. Panel A reports the patent applications by year and patent applications per firm by year. The number of patent applications in 2001 was 11.50 per firm and it reached 44.94 per firm in 2014. Panel B shows the patent applications and patent applications per firm by industry. On average, firms from the mining industry have the most patent applications (232.75 patent applications per firm), followed by firms in the information technology industry (68.83 patent applications per firm). As shown in Panel C of Table 1, the total number of patents of all listed firms and the average number of patents per firm have both been increasing during the sample period, especially after 2009. The average number of patents per firm was 17.38 in 2001, but increased to 61.58 in 2010 and 134.93 in 2014. The possible reasons for this rapid growth in patent applications include the development of the ChiNext Board, which mainly includes high-tech corporations, and government policy, as well as increased spending on innovation in China. A PwC study report by Jaruzelski, et al.(2015)[3] states that during 2007 and 2015, R&D imports to China grew 79%, helping to make it the second-largest destination for in-country R&D. In addition, led by dynamic growth in China and India, Asia is now the number one region for corporate R&D spending, followed by North America and Europe.

Table 2 reports the average stock holdings of the three institutional investors by year. We can see that the average holdings of mutual funds are much higher than those of QFII and GREY during the whole sample period. In 2014, the mean holding of mutual funds was 4.21%, while the mean holdings of QFII and GREY were 0.16% and 0.79%, respectively. Table 2 also shows the fast growing trend of various institutional investors' holdings. In 2001, the average mutual funds' holding was 0.6%; it reached a peak (6.07%) in 2009; and stayed reasonably stable until 2014 (4.21%). From Tables 1 and 2 we can see that, while

[3] This report is available online at https://www.strategyand.pwc.com/reports/2015-global-innovation-1000-media-report

Table 3
Descriptive statistics.

Variable	N	Mean	Median	Std. dev.	Min	Max
INV_APP	7442	20.112	3	168.371	0	5785
UTL_APP	7442	15.99	3	62.282	0	1745
DES_APP	7442	5.703	0	24.822	0	581
PATENT_APP	7442	41.805	10	215.384	0	6325
Ln(1+INV_APP)	7442	1.440	1.386	1.174	0	8.663
Ln(1+UTL_APP)	7442	1.409	1.099	1.314	0	7.503
Ln(1+DES_APP)	7442	0.612	0.000	1.102	0	6.366
Ln(1+PATENT_APP)	7442	2.323	2.197	1.223	0	8.752
MF	7435	0.053	0.013	0.084	0	0.677
GREY	7435	0.006	0	0.013	0	0.191
QFII	7435	0.002	0	0.009	0	0.223
TOP	7442	0.379	0.363	0.153	0.022	0.85
STATE	7442	0.145	0	0.226	0	0.857
DUAL	6593	0.227	0	0.419	0	1
IND	7394	0.354	0.333	0.072	0	0.8
BOARD	7394	2.203	2.197	0.213	1.099	2.944
MEETINGS	7442	2.101	2.079	0.383	0.693	4.043
ROA	7442	0.046	0.042	0.063	−0.711	1.207
GROWTH	7442	0.208	0.158	0.482	−0.822	16.188
CASH	7442	0.051	0.047	0.081	−0.684	1.093
LEV	7442	0.573	0.57	0.195	0.008	0.95
SIZE	7442	21.672	21.472	1.146	19.115	27.766
CHINEXT	7442	0.079	0	0.27	0	1
REGION	7427	0.492	0	0.5	0	1

Table 3 reports the descriptive statistics of all variables used in this study. The definitions of the variables can be found in the Appendix.

both firm innovation and institutional holdings increase significantly during our sample period, their growth trends are not the same.

Table 3 shows the descriptive statistics of all variables used in this study. The average value of both PATENT_APP and INV_APP are 41.805 and 20.112 respectively, which suggests that the numbers of patent applications of certain listed firms are quite high during the sample period and that, out of the three sub-categories of patents, invention patents are the most popular, followed by utility model patents and design patents. On average, the percentage of mutual funds' holdings in listed firms is 5.3%, which is almost nine times that of the average grey institutions' holdings (0.6%). Among the three types of institutions, QFIIs have the lowest holdings in listed firms, with an average value of only 0.2%. The ownership concentration of listed firms is relatively high, with a mean value of almost 38% during the sample period.

We first employ univariate tests to examine the differences in patent applications between firms with high and low institutional ownership. As reported in Panel A of Table 4, listed firms with higher mutual funds' ownership have more total patent applications, more invention patent applications, more utility model patent applications and more design patent applications. The differences between the mean and median values are all statistically significant. As only less than 50% of sample firms have shares held by grey institutions or QFIIs, we split the whole sample into two sub-samples; firms with, and without three types of different institutional ownership. As shown in Panels B, C and D of Table 4, listed firms with mutual funds' ownership, grey institutional ownership or QFII ownership have significantly higher patent applications than firms without these institutional ownerships do.

The empirical results of the multivariate analyses are reported in Table 5[4] . As shown in Table 5, the coefficients on MF are significantly positive at the 1% level, when the logarithm of one plus INV_APP, DES_APP, and PATENT_APP are used as the dependent variables. The coefficient of MF is 0.012 when Ln(1+PATENT_APP) is used as the dependent variable. Moreover, the economic significance is 0.043% given that the mean value of Ln(1+PATENT_APP) is 2.323[5] . On the other hand, the coefficients on GREY are only significantly positive at the 10% level, when these three variables are used as the dependent variables. Moreover, the coefficient on QFII is only positively significant at the 10% level when the logarithm of one plus DES_APP is employed as the dependent variable. As such, the empirical results reported in Table 5 indicate that mutual funds are more capable of improving the innovative activities of listed firms compared with grey institutions and QFIIs, supporting our hypothesis. The results on grey institutions and QFII are consistent with our expectations. Possible explanations could be that the ownerships of grey institutions and QFIIs in listed firms are relatively small (as reported in Table 2), that grey institutions have less monitoring effects due to the potential business connections with portfolio firms (Aggarwal et al., 2014), and that foreign investors are not at ease in a relatively unknown environment when dealing with domestic situations (Boubakri et al., 2005).

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4 We have tested the Pearson correlations among independent variables. The correlations are not high enough to cause multicollinearity. Due to space limitations, these results are not reported, but are available upon request.

5 We use the standard approach to calculate the economic significance as the coefficient of a variable times the standard deviation of the variable divided by the mean value of the dependent variable.

Table 4
Univariate analyses.

Panel A	MF top 50%		MF bottom 50%			
Variable	Mean value	Median value	Mean value	Median value	Mean diff t-value	Median diff z-value
Ln(1+PATENT_APP)	3.062	2.944	2.532	2.485	0.530*** *17.310*	0.460*** *15.599*
Ln(1+INV_APP)	1.910	1.792	1.308	1.099	0.602*** *21.130*	0.693*** *19.87*
Ln(1+UTL_APP)	1.740	1.609	1.398	1.386	0.342*** *10.720*	0.223*** *8.201*
Ln(1+DES_APP)	0.772	0	0.563	0	0.209*** 7.740	N/A
N	3694		3693			
Panel B	**MF>0**		**MF = 0**			
Variable	Mean value	Median value	Mean value	Median value	Mean diff t-value	Median diff z-value
Ln(1+PATENT_APP)	2.903	2.872	2.049	2.401	0.854*** *13.12*	0.471*** *12.600*
Ln(1+INV_APP)	1.651	1.787	1.289	1.055	0.362*** *19.12*	0.732*** *14.755*
Ln(1+UTL_APP)	1.597	1.513	1.341	0	0.256*** *12.23*	1.513*** *8.526*
Ln(1+DES_APP)	0.679	0	0.575	0	0.104*** *3.25*	N/A
N	6332		1055			
Panel C	**GREY>0**		**GREY = 0**			
Variable	Mean value	Median value	Mean value	Median value	Mean diff t-value	Median diff z-value
Ln(1+PATENT_APP)	3.078	2.996	2.662	2.565	0.416*** *12.6*	0.431*** *11.617*
Ln(1+INV_APP)	1.924	1.792	1.458	1.386	0.466*** *15.1*	0.405*** *14.69*
Ln(1+UTL_APP)	1.774	1.609	1.471	1.386	0.303*** *8.87*	0.223*** *7.481*
Ln(1+DES_APP)	0.759	0	0.623	0	0.136*** *4.69*	N/A
N	2398		4989			
Panel D	**QFII>0**		**QFII = 0**			
Variable	Mean value	Median value	Mean value	Median value	Mean diff t-value	Median diff z-value
Ln(1+PATENT_APP)	3.162	3.045	2.749	2.639	0.413*** *8.53*	0.405*** *7.481*
Ln(1+INV_APP)	2	1.792	1.558	1.386	0.442*** *9.71*	0.405*** *8.924*
Ln(1+UTL_APP)	1.876	1.792	1.529	1.386	0.347*** *6.94*	0.405*** *5.337*
Ln(1+DES_APP)	0.767	0	0.654	0	0.112** *2.65*	N/A
N	859		6528			

Table 4 reports the results of the univariate analyses. The definition of the variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels, respectively (two-sided).

Some of the results of the control variables are also interesting. DUAL is significantly and positively associated with the proxies for patent applications, which suggests that listed firms are more innovative when the board chair also holds the position of CEO. The coefficients on IND are significantly positive when the logarithm of one plus INV_APP, UTL_APP and PATENT_APP are employed as dependent variables. Therefore, having more independent directors on the board is helpful for promoting the innovation of listed firms. The coefficients on REGION are positively significant in most regressions. This is consistent with our expectation that listed firms from developed regions are more innovative.

As robustness check, we also test the impact of different institutional ownership on the changes of patent application, using the difference in patent applications between current year and previous year divided by patent applications in previous

Table 5
Fixed-effect regression results.

Variables	Ln(1+INV_APP) coefficient	*p value*	Ln(1+UTL_APP) coefficient	*p value*	Ln(1+DES_APP) coefficient	*p value*	Ln(1+PATENT_APP) coefficient	*p value*
Intercept	0.019***	*0.001*	0.030***	*0.001*	0.023***	*0.001*	0.072***	*0.001*
MF	0.008***	*0.001*	0.001	*0.871*	0.004***	*0.009*	0.012***	*0.001*
GREY	0.015*	*0.091*	0.004	*0.648*	0.014*	*0.086*	0.033*	*0.062*
QFII	−0.009	*0.471*	0.009	*0.481*	0.019*	*0.089*	0.018	*0.458*
TOP	0.001	*0.927*	0.001	*0.725*	0.001	*0.451*	0.001	*0.671*
STATE	−0.001	*0.247*	−0.002***	*0.003*	−0.001	*0.952*	−0.003**	*0.037*
DUAL	0.001***	*0.001*	0.001***	*0.001*	0.001**	*0.029*	0.002***	*0.001*
IND	0.006**	*0.015*	0.006**	*0.011*	−0.001	*0.469*	0.010***	*0.022*
BOARD	0.001*	*0.080*	−0.001	*0.250*	−0.002**	*0.011*	−0.001	*0.467*
MEETINGS	0.001	*0.143*	0.001*	*0.072*	−0.001	*0.454*	0.001	*0.182*
ROA	0.004	*0.101*	0.006***	*0.006*	−0.001	*0.519*	0.009*	*0.054*
GROWTH	0.001	*0.299*	−0.001	*0.815*	0.001	*0.311*	0.001	*0.843*
CASH	−0.002	*0.228*	−0.002	*0.309*	0.003**	*0.042*	−0.001	*0.835*
LEV	0.002***	*0.010*	0.001	*0.344*	0.001	*0.742*	0.002*	*0.092*
SIZE	−0.001***	*0.001*	−0.001***	*0.001*	−0.001***	*0.001*	−0.003***	*0.001*
CHINEXT	0.001	*0.390*	0.001	*0.158*	−0.001***	*0.003*	−0.001	*0.881*
REGION	0.001***	*0.001*	0.001	*0.108*	0.001***	*0.010*	0.001**	*0.028*
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	6528		6528		6528		6528	
R-square	0.035		0.039		0.019		0.057	

Table 5 reports the results of the fixed-effect regressions. Dependent variables are Ln(1+INV_APP), Ln(1+UTL_APP), Ln(1+DES_APP), and Ln(1+PATENT_APP), respectively. MF, GREY, and QFII are proxies for institutional ownerships. The definition of the variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels, respectively (two-sided).

year as the dependent variables. The results are reported in Panel A of Table 6. The evidence show that MF holdings are significantly and positively related to all patent application changes at the 1% or 10% level, while the grey institutional ownership is only positively related to design patent application change at the 5% level. The positive relationship between QFIIs and patent application changes disappear in this table.

As there is a chance that patent applications do not get granted, we also use actual patent numbers of a firm to measure innovation outputs. In Panel B of Table 6, the dependent variables are the difference in total number of different types of patents between current and previous year divided by total assets in millions. The results show that MF holdings are positively related to changes of invention patents, design patents and total patents at the 1% or 5% significance level, while grey institutional holdings are only positively related to changes of invention patents at the 1% level. Similarly, QFIIs have no significantly positive relations with the changes of the actual patent numbers.

We acknowledge that innovation inputs are also important to innovation outputs, and therefore we include natural logarithm of R&D expenses as an independent variable in the fixed effect regressions. Given there are too many missing data on R&D expenses, we cannot use this variable in the main regression in Table 5. The results with R&D expenses are provided in Table 7. We can see that R&D expenses are significantly and positively related to patent applications, patent application changes and actual patent number changes, indicating that the innovation inputs influence innovation outputs. After controlling for R&D expenses, MF holdings are still significantly and positively related to patent applications, patent application changes and actual patent number changes, while grey institutional ownership is only significantly and positively related to one of the dependent variables of patent applications, patent application changes or actual patent number changes. The QFII holdings are also only significantly and positively related to one of the measures of patent application changes or actual patent number changes.

It is noteworthy that there is potential endogeneity between institutional ownership and corporate patents, as mutual funds and other types of institutions may prefer to invest in innovative firms. As such, we adopt the following methods to address this endogeneity issue. First, we use one year lagged institutional ownership in our panel data fixed-effect regression analysis. Second, we apply the two-stage least squares (2SLS) estimation technique in our robustness tests. The key to 2SLS regressions is to have at least one appropriate instrument variable. The instrument variables used in our 2SLS regressions are ALPHA, BETA, and TURNOVER. ALPHA is the excess return of an individual stock relative to the return of the market index. It is the abnormal rate of return on individual stock in excess of what would be predicted by the CAPM model. BETA is the market beta coefficient for an individual stock. TURNOVER is the annual trading volume of an individual stock scaled by its total number of tradable shares. In the first stage regressions, one year lagged ALPHA, BETA, and TURNOVER are used to predict the value of institutional ownership. The predicted institutional ownership is then used as the independent variables in the second stage regressions.

As shown in Table 8, the instrument variables, namely ALPHA, BETA, and TURNOVER, are significantly associated with both MF and GREY in the first stage regressions. In the second stage regressions, the predicted MF is still significantly and positively associated with INV_APP, DES_APP, and PATENT_APP. This confirms that mutual funds have positive influence on the

Table 6
Fixed-effect regression results.

Panel A:

Variables	INV_RATE		UTL_RATE		DES_RATE		PATENT_RATE	
	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	−0.321	*0.363*	−0.301	*0.690*	0.812	*0.161*	0.353	*0.386*
MF	0.740***	*0.001*	1.182***	*0.007*	0.504*	*0.100*	0.680***	*0.003*
GREY	−1.148	*0.295*	−3.541	*0.127*	4.168**	*0.011*	−2.323*	*0.061*
QFII	2.248	*0.217*	−3.404	*0.411*	−3.725	*0.230*	0.382	*0.866*
TOP	0.194*	*0.080*	0.296	*0.221*	0.115	*0.520*	0.513***	*0.001*
STATE	0.125	*0.147*	0.037	*0.838*	0.389***	*0.004*	0.040	*0.674*
DUAL	0.084**	*0.021*	0.158*	*0.057*	0.032	*0.570*	0.033	*0.453*
IND	0.506*	*0.092*	0.510	*0.433*	−0.668	*0.163*	0.195	*0.571*
BOARD	0.016*	*0.091*	0.041**	*0.046*	0.004	*0.763*	0.034***	*0.001*
MEETINGS	0.009**	*0.040*	0.010	*0.332*	−0.014*	*0.051*	0.006	*0.224*
ROA	0.478	*0.081*	0.720	*0.233*	0.167	*0.695*	0.534*	*0.090*
GROWTH	−0.016	*0.527*	−0.009	*0.807*	−0.020	*0.476*	−0.013	*0.556*
CASH	−0.251	*0.195*	−0.051	*0.901*	−0.037	*0.901*	−0.120	*0.590*
LEV	−0.070	*0.460*	−0.142	*0.494*	−0.266*	*0.087*	−0.239**	*0.029*
SIZE	0.015	*0.342*	0.003	*0.930*	−0.013	*0.614*	−0.018	*0.326*
CHINEXT	−0.011	*0.863*	0.457***	*0.002*	0.138	*0.205*	0.112	*0.147*
REGION	−0.001	*0.992*	−0.126*	*0.057*	0.099**	*0.041*	−0.023	*0.515*
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	6206		6206		6206		6206	
R-square	0.014		0.01		0.011		0.01	

Panel B:

Variables	**ΔINV**		**ΔUTL**		**ΔDES**		**ΔPATENT**	
	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.004***	0.001	0.016***	<.0001	0.006***	0.016	0.027***	<.0001
MF	0.002***	<.0001	0.002	0.115	0.003**	0.021	0.008***	0.001
GREY	0.009***	0.006	0.002	0.778	0.003	0.742	0.014	0.285
QFII	−0.009	0.138	0.018	0.245	−0.005	0.753	0.004	0.866
TOP	0.001	0.766	0.001	0.215	0.001	0.550	0.002	0.224
STATE	−0.001***	0.001	−0.002**	0.018	0.001	0.503	−0.002*	0.055
DUAL	0.001***	0.001	0.001***	<.0001	0.001	0.274	0.002***	<.0001
IND	0.003***	0.001	0.005**	0.047	0.001	0.564	0.009**	0.015
BOARD	0.001***	<.0001	−0.001	0.905	0.001	0.738	0.001	0.207
MEETINGS	0.001	0.724	0.001	0.112	−0.001	0.327	0.001	0.619
ROA	0.001	0.841	0.007***	0.001	0.001	0.454	0.008***	0.009
GROWTH	−0.001	0.372	−0.001	0.707	−0.001	0.250	−0.001	0.247
CASH	−0.001	0.578	−0.002*	0.100	0.001	0.937	−0.003	0.259
LEV	0.001***	0.001	0.001	0.386	−0.001	0.346	0.001	0.359
SIZE	0.000***	<.0001	−0.001***	<.0001	−0.001**	0.015	−0.001***	<.0001
CHINEXT	0.001**	0.044	0.002***	0.003	0.001	0.357	0.002***	0.004
REGION	0.001***	<.0001	−0.001	0.673	0.001	0.165	0.001*	0.088
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	6263		6263		6263		6263	
R-square	0.035		0.025		0.003		0.028	

Table 6 Panel A reports the results of fixed-effect regressions. Dependent variables are INV_RATE, UTL_RATE, DES_RATE, and PATENT_RATE, respectively. MF, GREY, and QFII are proxies for institutional ownership. The definition of variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels respectively (two-sided).
Table 6 Panel B reports the results of fixed-effect regressions. Dependent variables are ΔINV, ΔUTL, ΔDES, and ΔPATENT, respectively. MF, GREY, and QFII are proxies for institutional ownership. The definition of variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels respectively (two-sided).

innovative behaviours of listed firms. However, the predicted grey institutional ownership is only significantly and positively associated with DES_APP, which provides support to the results in Table 5, that grey institutions have an insignificant impact on firm innovation.

Third, to further control for the potential endogeneity between institutional holdings and corporate innovation, we employ system generalized method of moments (GMM) techniques developed by Arellano and Bover (1995) and Blundell and Bond (1998) in dynamic panel data. The system GMM in dynamic panel data can alleviate the possible positive bias in difference GMMdue to the persistence of lagged dependentvariablesas instruments (Blundell and Bond, 1998). The results

Table 7
Fixed-effect regression results (with R&D).

Panel A	Ln(1+INV_APP)		Ln(1+UTL_APP)		Ln(1+DES_APP)		Ln(1+PATENT_APP)	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.035***	*0.001*	0.042***	*0.001*	0.002	*0.320*	0.079***	*0.001*
MF	0.016***	*0.001*	0.010***	*0.004*	0.002**	*0.050*	0.028***	*0.001*
GREY	0.046**	*0.033*	−0.012	*0.537*	0.006	*0.416*	0.040	*0.274*
QFII	−0.023	*0.629*	−0.025	*0.557*	−0.001	*0.947*	−0.049	*0.549*
R&D	0.001***	*0.001*	0.001***	*0.001*	0.001	*0.134*	0.002***	*0.001*
Control Variables	YES		YES		YES		YES	
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	1561		1561		1561		1561	
R-square	0.058		0.050		0.022		0.063	
Panel B	INV_RATE		UTL_RATE		DES_RATE		PATENT_RATE	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.501	*0.394*	2.163	*0.464*	0.098	*0.882*	2.095***	*0.003*
MF	1.214***	*0.001*	3.248**	*0.049*	−0.079	*0.818*	0.700*	*0.068*
GREY	−1.213	*0.473*	−3.340	*0.710*	4.951**	*0.012*	−1.498	*0.475*
QFII	11.200**	*0.016*	−12.481	*0.670*	5.853	*0.341*	9.338	*0.105*
R&D	0.035**	*0.011*	0.053	*0.467*	0.036**	*0.035*	0.033*	*0.055*
Control Variables	YES		YES		YES		YES	
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	1465		1465		1465		1465	
R-square	0.032		0.017		0.031		0.021	
Panel C	ΔINV		ΔUTL		ΔDES		ΔPATENT	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.501	*0.394*	2.163	*0.464*	0.098	*0.882*	2.095***	*0.003*
MF	1.214***	*0.000*	3.248**	*0.049*	−0.079	*0.818*	0.700*	*0.068*
GREY	−1.213	*0.473*	−3.340	*0.710*	4.951**	*0.012*	−1.498	*0.475*
QFII	11.200**	*0.016*	−12.481	*0.670*	5.853	*0.341*	9.338	*0.105*
R&D	0.035**	*0.011*	0.053	*0.467*	0.036**	*0.035*	0.033*	*0.055*
Control Variables	YES		YES		YES		YES	
Industry-fixed effects	YES		YES		YES		YES	
Year-fixed effects	YES		YES		YES		YES	
No. of obs.	1465		1465		1465		1465	
R-square	0.080		0.034		0.015		0.037	

Table 7 reports the results of fixed-effect regressions. In Panel A, dependent variables are Ln(1+INV_APP), Ln(1+UTL_APP), Ln(1+DES_APP), Ln(1+PATENT_APP), respectively. In Panel B, dependent variables are INV_RATE, UTL_RATE, DES_RATE, and PATENT_RATE, respectively. In Panel C, dependent variables are **Δ**INV, **Δ**UTL, **Δ**DES, and **Δ**PATENT, respectively. MF, GREY, and QFII are proxies for institutional ownerships. R&D is the natural logarithm of the R&D expenses. The definition of variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels respectively (two-sided).

of system GMM estimators in dynamic panel data models are reported in Table 9. The Sargan tests (*p-value>0.1*) do not suggest rejection of the overidentifying restrictions at conventional levels for either specification estimated. Furthermore, there is evidence of first order serial correlation in the residuals, and the AR(2) test statistics (*p-value>0.1*) reveals absence of second-order serial correlation in the first-differenced errors. Therefore, the instruments used in the system GMM model are valid. Mutual funds' holdings are positively related to the invention patent applications and total patent applications. However, the grey institutional holdings have insignificant impact on patent applications. Those results are similar to those of 2SLS regressions.

5. Conclusions

Innovation is of great interest to firm managers, employees, investors and regulators given its significant impact on firm long-run development (Fang et al., 2014). Using the sample period from 2001 to 2014, we investigate how institutional ownership influences firm innovation in China. We distinguish the institutions into three groups, namely mutual funds, grey institutions (including insurance companies and pension funds) and QFIIs, based on their holding sizes and potential business relations with portfolio firms. We find that mutual funds' holdings significantly increase firm innovation outputs in Chinese firms, measured by patent applications. However, grey institutional holdings and QFII holdings have less or no significant impact on innovations. Our results are robust after employing different innovation measures and controlling for firm financial performance, firm governance, regions, listing boards and possible endogeneity.

Table 8
2SLS Regression results.

First Stage	MF		GREY			
Variables	coefficient	*p value*	coefficient	*p value*		
Intercept	−0.333***	*0.001*	−0.037***	*0.001*		
ALPHA	5.039***	*0.001*	0.128**	*0.016*		
BETA	−0.034***	*0.001*	−0.001**	*0.042*		
TURNOVER	−0.002***	*0.001*	−0.001***	*0.001*		
Control Variables	YES		YES			
Industry-fixed effects	YES		YES			
Year-fixed effects	YES		YES			
R-square	0.209		0.056			
No. of obs.	6690		6690			
Second Stage (MF)	Ln(1+INV_APP)		Ln(1+DES_APP)		Ln(1+PATENT_APP)	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.025***	*0.001*	0.037***	*0.001*	0.082**	*0.001*
Predicted MF	0.020**	*0.038*	0.041***	*0.001*	0.039**	*0.032*
Control Variables	YES		YES		YES	
Industry-fixed effects	YES		YES		YES	
Year-fixed effects	YES		YES		YES	
R-square	0.031		0.020		0.054	
No. of obs.	6514		6514		6514	
Second Stage (GREY)	Ln(1+INV_APP)		Ln(1+DES_APP)		Ln(1+PATENT_APP)	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
Intercept	0.023*	*0.001*	0.041***	*0.001*	0.076***	*0.001*
Predicted GREY	0.143	*0.317*	0.440***	*0.001*	0.206	*0.452*
Control Variables	YES		YES		YES	
Industry-fixed effects	YES		YES		YES	
Year-fixed effects	YES		YES		YES	
R-square	0.03		0.018		0.054	
No. of obs.	6514		6514		6514	

Table 8 reports the results of the 2SLS regressions. In the first stage, the dependent variables are MF and GREY. Instrument variables, namely ALPHA, BETA, and TURNOVER, are used to predict the values of MF and GREY. In the second stage, the dependent variables are Ln(1+INV_APP), Ln(1+DES_APP), and Ln(1+PATENT_APP). The predicted values of MF and GREY obtained from the first stage are used as independent variables. The definition of the variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels, respectively (two-sided).

Table 9
Results of System GMM estimators in dynamic panel data model.

System GMM estimators in dynamic panel data model						
	Ln(1+INV_APP)		Ln(1+DES_APP)		Ln(1+PATENT_APP)	
Variables	coefficient	*p value*	coefficient	*p value*	coefficient	*p value*
LAG_IA	0.395***	*0.001*				
LAG_DA			0.380***	*0.001*		
LAG_PA					0.303***	*0.001*
MF	*6.537****	*0.005*	*3.591*	*0.508*	4.676*	*0.098*
GREY	*−15.671*	*0.405*	*5.157*	*0.862*	−18.316	*0.383*
Control Variables	*YES*		*YES*		YES	
Industry-fixed effects	YES		YES		YES	
Year-fixed effects	YES		YES		YES	
Sargan test	0.108		0.112		0.653	
AR(1)	0.001		0.001		0.001	
AR(2)	0.664		0.856		0.125	
No. of obs.	5686		5686		5686	

Table 9 reports the results of the System GMM estimators in dynamic panel data model. The one-year lagged dependent variables are used as independent variables in the regressions. LAG_IA, LAG_DA, and LAG_PA are the one-year lagged value of Ln(1+INV_APP), Ln(1+DES_APP), and Ln(1+PATENT_APP), respectively. The dependent variables are Ln(1+INV_APP), Ln(1+DES_APP), and Ln(1+PATENT_APP). The definition of the variables can be found in the Appendix. *, **, *** represent the statistical significance at the 0.1, 0.05, and 0.01 levels, respectively (two-sided).

Given the important role of innovation in Chinese sustainable economic development and the current low property right protection environment in China, our findings suggest to the policy makers that developing mutual funds and increasing institutional holdings will be beneficial to firm innovation and the property right protection environment in China. Our results add new evidence to the literature on the positive role played by institutional investors in emerging economies.

Appendix A

Variable definitions

Variable	Definition
Dependent variables	
PATENT_APP	Total number of patent applications in a firm in a particular year
INV_APP	The number of invention patent applications in a firm in a particular year
UTL_APP	The number of utility model patent applications in a firm in a particular year
DES_APP	The number of design patent applications in a firm in a particular year
PATENT_RATE	The difference in patent applications between current year and previous year/patent applications in previous year
INV_RATE	The difference in invention patent applications between current year and previous year/invention patent applications in previous year
UTL_RATE	The difference in utility patent applications between current year and previous year/utility patent applications in previous year
DES_RATE	The difference in design patent applications between current year and previous year/design patent applications in previous year
△PATENT	The difference in total number of approved patents between current and previous year/total assets (millions)
△INV	The difference in the number of invention patents between current and previous year/total assets (millions)
△UTL	The difference in the number of utility model patents between current and previous year/total assets (millions)
△DES	The difference in the number of design patents between current and previous year/total assets (millions)
Main independent variables	
MF	Percentage of shares held by mutual funds
GREY	Percentage of shares held by insurance companies, public pension funds, and/or corporate pension funds
QFII	Percentage of shares held by QFIIs
Control variables	
TOP	Percentage of shares held by the largest shareholder
STATE	Percentage of shares held by the state shareholders
DUAL	A dummy variable, which equals one if the board chair is also the CEO, 0 otherwise.
IND	The proportion of independent directors
BOARD	The number of people on the board of directors
MEETINGS	The number of board meetings in a year
ROA	Net income over total assets
GROWTH	Sales growth rate
CASH	Operating cash flow scaled by total assets
LEV	Total debt over total assets
SIZE	The natural logarithm of total assets
CHINEXT	A dummy variable, which equals one if a firm is listed on the ChiNext board, 0 otherwise.
REGION	A dummy variable, which equals one if a firm's headquarter is in developed regions in China, namely Beijing, Shanghai, Guangdong, Jiangsu, or Zhejiang, 0 otherwise.
Instrument variables	
ALPHA	The excess return of an individual stock relative to the return of the market index
BETA	Market beta coefficient for an individual stock
TURNOVER	The annual trading volume of an individual stock scaled by its total number of tradable shares

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