







Heterogenic institutional investors and their influence on corporate innovation: Evidence from a transition economy



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Purpose: The literature lacks a specific mechanism that may help to explain the variation in corporate innovation. This research helps to explain a specific mechanism that affects corporate innovation.

Design/methodology/approach: Ordinary Least Square (OLS) regression has been used to analyse the data collected from Chinese manufacturing firms listed on Shenzhen and Shanghai Stock Exchanges from 2007 to 2015. Innovation input has been measured through research and development (R&D) expense scaled by total assets, while the number of forward invention patent citations has been used to measure the quality of innovation performance.

Findings/results: The results show that pressure-resistance institutional investors (PR institutions) encourage, while pressure-sensitive institutional investors (PS institutions) discourage R&D intensity. Additionally, exploring the efficiency logic, results show that PR institutions positively moderate both in SOEs (state-owned enterprises) and non-SOEs, while in contrast, PS institutions negatively moderate only in non-SOEs. Overall, the results support our argument that institutional investors' business relations act as a mechanism that affects not only their fiduciary responsibilities, but also their proneness to pressure which in turn affects corporate innovation.

Practical implications: There is a great need to protect institutional investors from forming business relations with firms in which they invest. This strategy will help institutional investors to perform their valuable role in enhancing corporate innovation.

Originality/value: The article contributes to the existing literature by highlighting institutional investors' heterogenic behaviour. Second, this research highlights institutional investors' business relations, which affect R&D intensity and innovation performance.

Keywords: corporate innovation; pressure-sensitive institutional investors; pressure-resistance institutional investors; R&D intensity; institutional investors; China.

Introduction

Innovation is a very significant corporate decision, and firms invest a large amount of resources to be successful in innovation (Ucar, 2018). The literature on corporate innovation highlights many factors that affect corporate innovation. Financial literature shows that institutional ownership is a key variable that affects a manager's decisions regarding innovation and risk-taking (Aghion, Van Reenen, & Zingales, 2013; Baysinger, Kosnik, & Turk, 1991). Usually, managers avoid innovations because of uncertainty, capital intensity, long-term nature, and stochastic reasons – things going wrong purely as a result of some other random occurrences (Unsal & Rayfield, 2019). To overcome this phenomenon, institutional investors are viewed as an effective external corporate governance mechanism having the capabilities to enhance corporate innovation (Chang, Liang, & Wang, 2019; Choi, Lee, & Williams, 2011; Xu, Wang, & Cheng, 2015). However, the influence of institutional investors on innovation is a mix, full of contradictions and they vary because of their types (Aghion 2013; Bushee, 1998), roles (Kochhar & David, 1996), and heterogeneous characteristics (Brickley, Lease, & Smith, 1988). The literature however, lacks a specific mechanism through which how institutional investors can affect research and development (R&D) intensity and innovation performance can be highlighted.

The previous literature is unclear and indecisive in highlighting the channel through which the institutional investors may affect corporate innovation. Aghion et al. (2013) highlight that the career

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concern model – where institutional owners increase innovation incentives through reducing career risks – is the effective primary mechanism that safeguards managers from innovation's stochastic factors. Contrarily, Berger, Stocker and Zeileis (2017) argue that the career concern model heavily depends on the model framework and claim that by using the count data hurdle model for analysis, neither the career concern model nor lazy managers' hypothesis – managers prefer a quiet life and institutional investors force them to innovate – satisfactorily explain the mechanism. Therefore, to know the channel through which institutional investors affect corporate innovation, there is a strong need to carefully examine the impact of institutional investors on corporate innovation using the same categorisation of institutional investors as used by Brickley et al. (1988) and David, Kochhar and Levitas (1998). This study, therefore, has two basic aims to explore. Firstly, this study intends to investigate the influence of pressure-resistance (PR) and pressure-sensitive (PS) institutions on R&D intensity and corporate innovation in state-owned enterprises (SOEs) – a legal entity created by a government to partake in commercial activities on the government's behalf, either wholly or partially owned by a government – and non-SOEs in China. Secondly, the study explores how PR institutional investors (PR institutions) and PS institutional investors (PS institutions) differ in affecting the association between innovation input (R&D intensity) and innovation output (corporate innovation).

This study uses a unique dataset of Chinese institutional investors from 2007 to 2015, Chinese manufacturing firms listed as A-shares on the Shenzhen Stock Exchange and Shanghai Stock Exchange. We found that PR institutions have a positive, while PS institutions have a negative impact on R&D intensity. These findings show that because of the absence of PR institutions' business relations, they focus more on the long-term perspective than the short-term perspective; this is why firms invest more in innovative projects. Further, the study reveals that PR institutions have a positive impact on R&D intensity only in SOEs. By contrast, PS institutions have a negative impact on R&D intensity only in non-SOEs. Additionally, we found that PR institutions strongly influence innovation performance as compared to PS institutions. We also found that PR institutions positively moderate the association between R&D intensity and innovation performance both in SOEs and non-SOEs. These results show the importance of PR institutions, and highlight their significance in both the SOEs and non-SOEs. Furthermore, PS institutions negatively moderate the associations between the R&D intensity and innovation performance only in non-SOEs.

This research contributes to the existing literature in many ways. Firstly, this research has a methodological contribution. Both the studies of Brickley et al. (1988) and David et al. (1998) used cross-sectional data. However, the nature of cross-sectional data specifically for innovation in the study of Kochhar and David (1996) left a wider gap for improvement. More importantly, Brickley et al. (1988) used homogenous institutional categorisation to study their impact on voting

for anti-takeover amendments, while Kochhar and David (1996) used the same categorisation for corporate innovation (measured through new product development). Our study is the first that uses the heterogenic categorisation of institutional investors based on their disparate behaviour derived from their business relations. Furthermore, this study uses more robust methods to measure corporate innovation through forward invention patents citation, which is much better than new product development used by Kochhar and David (1996) earlier in their research to measure corporate innovation. So, these are the business relations of institutional investors with the factor firms which make them different from each other (i.e. heterogenous from each other) and make these institutions behave differently with different firms.

Secondly, categorising the institutions into PR and PS institutional investors provides new insights towards R&D intensity. Our study confirms the myopic investor hypothesis viewpoint for the first time by having this unique institutional categorisation, which complements the results of Graves (1988), who identified that institutional investors (in general) have a negative effect on innovation (R&D intensity). Our study is consistent with Graves (1988) research by finding that only PS institutional investor has a negative impact on R&D intensity, while in contrast, PR institutions have a positive impact on R&D intensity. This study strengthens the viewpoint that PS institutions do foster short-term orientation and are sensitive to short-term gains instead of long-term gains through corporate innovation.

Thirdly, as discussed earlier that not only ownership structure (Rong, Wu, & Boeing, 2017), rather the role of institutional investors (Chi, Liao, & Yang, 2019) also differs in China. More specifically, there is a lack of empirical evidence regarding these heterogenic institutions and their impact on corporate innovation in SOEs and non-SOEs. We fill this gap by finding that PR institutions only have a positive impact on R&D intensity in SOEs, while they have no effect in non-SOEs. On the other hand, PS institutions have a negative influence on R&D intensity only in non-SOEs, and have no impact on SOEs. Moreover, we also investigated the influence of institutional investors on corporate innovation performance in SOEs and non-SOEs.

Finally, this study deals with the efficiency logic which refers to firms' capabilities to utilise their own resources with full potential. We highlight that institutional investors have heterogenous characteristics; therefore, institutional investors differ in their capabilities to affect the efficient utilisation of research funds which in turn affects corporate innovation.

Theoretical framework and hypothesis development

When institutional investors are dissatisfied with a firm's performance, they do not coerce the board to fire managers because most of the time, they do not have adequate representation on the board to do so (Aghion et al., 2013).

However, institutions can pressurise boards to take action on their behalf and take corrective measures to safeguard their interests. This is only possible if institutional investors have the capacity and competence to pressurise boards, and it is only possible if institutions do not depend on the investing firms for their own business operations (Brickley et al., 1988). Business relations and institutional investors' dependence on their investing firms affect their fiduciary responsibilities, which is why these institutions can be categorised into heterogenic groups based on their business relations and proneness to pressures (Brickley et al., 1988). These categorisations of institutions into PR, PS, and pressure-indifferent institutions (Brickley et al., 1988; Kochhar & David, 1996) also help identify which institutions act as monitors with long-term interests and which institutions act myopic by acquiring short-term benefits. Similarly, pointing towards the efficiency logics, PR institutional investors can act as monitors and fabricate strategies that may enhance resource utilisation, utilisation of research, and development funds in specific, to enhance innovation output.

Hypothesis development

Pressure-sensitive institutions and research and development intensity

Despite institutions' business relations, other elements affect the association between institutions and corporate innovation. One of those factors is the lack of firm-specific information in less developed economies (Ebrahimnejad & Hoseinzade, 2019), making it hard to evaluate the true long-term significance of that company (Porter, 1992). Institutional investors' capabilities are limited to monitoring each firm in their portfolios' capabilities and monitoring each firm in their portfolios (Ward, Yin, & Zeng, 2020). Therefore, institutions use information related to firm performance and current corporate earning that is easily accessible. However, this information loses sight of long-term performance and does not possess long-term innovation and competitiveness. In this uncertain situation, institutional investors, specifically PS institutions, behave like arbitragers and turn their portfolios frequently to capitalise on short-term gains rather than long-term. Therefore, managers cut R&D expenditure to boost short-term earnings and keep institutions satisfied at the cost of long-term corporate performance, innovation, and competitiveness (Bushee, 1998, 2001; Rong et al., 2017). Therefore we hypothesise that:

H1: There is a *negative* relationship between PS institutional investors and R&D intensity.

Pressure-resistance institutional investors and research and development intensity

Some specific types of institutional investors are more helpful for R&D investments. Institutions such as long-term-oriented institutions are considered more aligned with the corporate innovation's timeframe and help encourage R&D. However, the mechanism through which institutions affect innovation varies. The quite-life hypothesis suggests that managers try to avoid innovation (Bertrand & Mullainathan, 2003), but institutional investors encourage managers to innovate

(Aghion et al., 2013). On the other hand, a prominent viewpoint highlights another mechanism of the career-concern hypothesis. This viewpoint suggests that institutions safeguard managers against stochastic reasons behind innovation and the risk of being fired from their jobs as a result of adverse consequences if innovation ventures fail (Aghion et al., 2013). This is why institutions, especially PR institutions that are free from business dependence (Brickley et al., 1988), safeguard managers from career risks and encourage them to finance innovative ventures. Therefore, we hypothesise that:

H2: There is a *positive* relationship between PR institutional investors and R&D intensity.

Pressure-resistance versus pressure-sensitive institutional investors and innovation performance

Some of the institutional investors have a business relationship with the companies in which they invest. This helps to generate an economic activity that affects the operating income of institutions. The ability of institutions to affect firms' decisions in which they invest heavily rests on their dependence on a business relationship (Brickley et al., 1988). Pressure-resistance institutions do not depend on firms in which they hold equity to survive their business operations (Kochhar & David, 1996). This is the reason that PR institutions perform their fiduciary responsibility better than other institutions and pressurise management to safeguard their interests in firms, and try to gear activities towards long-term perspectives such as corporate innovation.

On the other hand, PS institutions have ongoing business relations with the factor corporations to acquire economic benefits to smoothen their business operations (Brickley et al., 1988). Therefore, the influence that these institutions can exert on a firm's board and management deriving from the power of ownership are refuted by their dependence on business relations (Finkelstein, 1992). Hence, these institutions having such business relations hesitate to questions or influence executive action. This is why if these institutions try to raise their voice against the myopic managerial activities, they are threatened for the withdrawal of the business on which these institutions depend. Therefore, this dependence makes these PS institutions more prone to risk, making these institutions unable to influence managers to pursue long-term, risky and innovative projects. Therefore we hypothesise that:

H3: PR institutional investors are more positively related to innovation performance than PS institutional investors.

The moderating role of pressure-resistance institutions on the association between research and development intensity and innovation performance

Pressures-resistance institutional investors not only induce pressures on the board as a result of the absence of business relations, instead, they also ensure that they are fully updated because of the significant stakes in the corporations in order to perform timely informed decisions. If the financial institutions prefer to invest in those firms that favour short-

term gains, consequently, these institutions underestimate the expected gains in the long run (Jensen, 1988). This is the reason that rational stakeholders evaluate their investments in a particular firm based on entirely accessible public information (Gibbons, Iliev, & Kalodimos, 2020). Therefore, these institutions value those expenditures, which are mandatory to enhance corporate value in the long run. Most of the time, shareholders having significant holdings in the equity thus weighing their investments with more care, and therefore they can make optimum investment decisions (Aoki, 1984). Hence, the key to successful investment evaluation and optimum portfolio selection is based on accessible public information. This is the reason that institutional investors possess more knowledge regarding the market as compared to individual investors. Therefore, the PR institutions having no business relations with the firms in which they invest are better positioned to pressurise the board and managers to optimally utilise the available resources favouring long-term gains through innovative projects in light of this information.

The large proportions of equity holdings by the PR institutions serve as a trap for these institutions. These two conditions of significant shareholding and the absence of PR institutions' business relations threaten these institutions about the two possible scenarios (Kochhar & David, 1996). First, these PR institutions cannot sell their equity in large blocks because it may lead to a considerable loss in stock prices, making this option unpleasant (Aoki, 1984). Second, let us assume that these PR institutions are capable of trading their stocks in the stock market through some means; even then, they may face difficulties in finding new avenues for investments because of the well-diversified portfolios of institutions (Gilson & Kraakman, 1991). These two factors of potential loss in equity market prices and deficiency of feasible future ventures, along with the ability to pressurise the boards, set the ground for PR institutions to actively monitor the boards and management for long-term gains through innovative ventures:

H4: PR institutional investors *positively moderate* the relationship between R&D intensity and innovation output.

The moderating role of pressure-sensitive institutional investors on the association between research and development intensity and innovation performance

In fact, initiating an R&D project depends on two things: its impact on a company's long-term profitability and its visibility and acceptance in the market (Rong et al., 2017). Therefore, continuous pressure from the market compels short-termism managers to select such ventures that are more observable to financiers (Ferreira, Manso, & Silva, 2014). Therefore, managers may try to relinquish R&D ventures and pursue more conservative and visible projects (Rong et al., 2017). This kind of short-termism by managers is further aggravated by speculative institutional investors, which show little interest in firms' long-term performance (Rong et al., 2017), such as PS institutions. This kind of situation is well documented by (Bushee, 1998, 2001), those

institutions which focus on short-term gain can compel managers to waive innovative projects for the sake of high short-term performance. Therefore, we hypothesise that:

H5: PS institutional investors *negatively moderate* the relationship between R&D intensity and innovation output.

Methods

Sample and data

To test the hypothesis, we collected data from Chinese manufacturing firms listed as A-shares on the Shenzhen Stock Exchange and Shanghai Stock Exchange. We chose 2007 as the initial study year because China Securities Regulatory Commission (CSRC) mandated listed companies since 2007 to reveal detailed information related to changes in equity and ownership. Moreover, new accounting rules for listed firms were also introduced in 2007. On the other hand, we terminated our data in 2016 to overcome the problem of citation truncation (there are fewer citations for later patents, normally citations need 5 years of a window to observe them) because the citation of a patent typically peak within 5 years since it is granted (Fleming & Sorenson, 2001; He & Tian, 2013).

We concentrated only on listed manufacturing firms because firms in manufacturing industries are assumed to be more dynamic than firms from other industries, and provide more opportunities for each firm to compete through successful products and technology breakthroughs (Piperopoulos, Wu, & Wang, 2018). Moreover, to collect data for corporate innovation, we referred to the SIPO of China database because it offers comprehensive information concerning the patent's data. Simultaneously, the data related to innovation intensity (R&D expense), firm performance, and corporate governance was collected from the China Stock Market & Accounting Research (CSMAR) Database. Data related to institutional ownership was collected from the Wind Financial Database (Bromiley & Washburn, 2011; Jiang & Yuan, 2018). We also obtained data on financial performance and corporate governance for each company from the CSMAR Database.

Variables

Dependent variables

Innovation input: We measured the innovation input by R&D expense (scaled by total assets) in a given year. R&D expense has been considered a critical form of creativity and innovation efforts that can serve as a useful proxy for innovation input in an organisation (Greve, 2003).

Innovation performance: Patents have three subcategories: utility model patents, design patents, and invention patents (Chi et al., 2019). In previous studies like Griliches (1981), the number of patents was used to measure the quantity (i.e. speed) of R&D activities rather than the quality of innovation output (Chang et al., 2019). Therefore, we used the number of forward invention patent citations to measure the quality of innovation, excluding self-citation for each year (Rong et al., 2017; Wagner & Wakeman, 2016; Zhong, 2018), which

captures the technical and market value of the patents of each firm (Wagner & Wakeman, 2016).

Independent variables

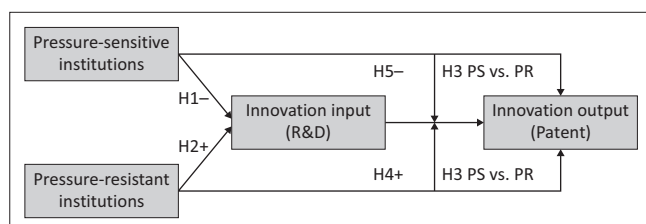
Pressure-sensitive institutional ownership: Consistent with prior research, PS institutional investors are influenced by the firms they invest in and had fewer chances to interfere in corporate decisions (Brickley et al., 1988; Rong et al., 2017). These institutional investors included insurance funds, securities companies, trust companies, banks, and financial companies that have an association with companies. To measure the pressure-sensitive institutional ownership, we sum up the proportion of shares held by these pressure-sensitive institutions.

Pressure-resistant institutional ownership: Following the study of Kochhar and David (1996), PR institutional investors had neglectable relation with the factor corporation, so these kinds of investors may play an efficient role in corporate governance and innovation decision. Social security funds, securities investment funds, and qualified foreign institutional investors (QFII) were regarded as PR institutional investors. Furthermore, we measure the institutional ownership at different ownership levels, such as at least 0%, 1%, and 5% (as blocker holder) of a firm's equity. Figure 1 illustrates the conceptual diagram to better understand the variables and hypothesis of the study.

Control variables

This study used a diverse range of control variables, which may influence innovation performance. The control variables include:

- *Firm size* was measured by the natural log of the firm's asset (Cherkasova & Kurlyanova, 2019; Chi et al., 2019). Generally, large firms possess more resources (financial, skilled works, innovation expertise, and marketing skills) than small firms.
- *Firm age* was measured by the number of years since its incorporation (Medase & Barasa, 2019).
- *Leverage* was measured by total liability divided by total assets at the end of the year (Ali, Yang, Sarwar, & Ali, 2019; Su, Xiao, & Yu, 2018).
- *Growth* was calculated as the firm's sale growth rate (Chi et al., 2019).
- *State Ownership* was measured as a dummy variable equal to 1 if the company is a SOE, and is 0 otherwise (Chi et al., 2019; Ndiaye, Razak, Nagayev, & Ng, 2018).



R&D, research and development; PR, pressure-resistant; PS, pressure-sensitive.

FIGURE 1: Conceptual framework.

- *Profitability* was measured by the net income divided by total assets (Song, Ai, & Li, 2015).
- *Industry competition* (Herfindahl–Hirschman Index [HHI]) was measured by the sum of squares of the percentages of sales of the focal firm in each industry based on 3-digit Standard Industrial Classification (SIC) (Zhou, Gao, & Zhao, 2017).
- *R&D intensity* is operationalised as the ratio of R&D expenses to sales (Feng & Johansson, 2018; Yang, Ali, Ali, Sarwar, & Khan, 2020).
- Property, plant, and equipment (PPE) also affect the innovation output because firms with more resources have extra capability to invest more in R&D projects and innovate more, which affects innovation output and innovation quality as well. Therefore, PPE was taken as a control variable measured as total fixed assets divided by the total assets.

We also included industry dummy variables and year dummy variables in our regression to control industry and time fixed effects (Chang et al., 2019; Ding, Jia, Wu, & Zhang, 2014). The main variables are described in Table 1.

Estimation method

To test our hypothesis, we employed Ordinary Least Square (OLS) regressions in a fixed-effect model. The Hausman Specification Test was performed, and on the basis of its

TABLE 1: Variables and data sources.

Variables	Description	Sources
Innovation input	Research and development expense scaled by total assets	CSMAR
Innovation performance	The number of forward invention patent citations a firm has received in natural logarithmic form	SIPO, China
PR institutions (N, %)	PR institutional ownership, public pension funds, mutual funds, and endowments and foundations (owning at least N percent of a firm's equity, N = 0, 1, 5)	Calculated from annual reports of the listed companies and website of institutional investors
PS Institutions (N, %)	PS institutional ownership, insurance companies, banks, and nonbank trusts (owning at least N percent of a firm's equity, N = 0, 1, 5)	Calculated from annual reports of the listed companies and website of institutional investors
Firm size	The natural logarithm of the total number of employees	CSMAR
Firm age	The firm's founding year subtracted from the observation year	CSMAR
Leverage	Total debt over total assets	CSMAR
Profitability	The net margin of equity (ROE)	CSMAR
Growth	Increase the rate of operating revenue	CSMAR
PPE	The net value of fixed assets over total assets	CSMAR
Board Size	The natural logarithm of the number of directors in the boardroom	CSMAR
SOE	The dummy variables equal to 1 if the company is a SOE and is 0 otherwise	CSMAR
HHI	The Herfindahl index to measure industrial competition	CSMAR
Market development	NERI index on market development	NERI index database

Note: This table reports the names of variables included in this study along with the measurement techniques and data sources. Innovation input illustrates R&D intensity. Pressure-resistance institution is an independent variable and illustrates PR institutional investors. Pressure-sensitive institution is also an independent variable and illustrates PS institutional investors.

CSMAR, China Stock Market & Accounting Research; SIPO, State Intellectual Property Office; PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl–Hirschman Index; NERI, The National Economic Research Institute; ROE, Return on Equity.

TABLE 2: Descriptive statistics and correlations.

Number	Variable	Mean	Standard deviation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1)	Innovation input	0.0188	0.0153	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(2)	Innovation performance (IP)	1.148	1.505	0.2921***	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(3)	Innovation performance (IPC)	0.517	1.140	0.0842***	0.5868***	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(4)	PR institutions (0%)	0.0763	0.121	0.0897***	0.1250***	0.4811***	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(5)	PS institutions (0%)	0.0087	0.0217	-0.00160	0.0313***	0.0916***	0.0147	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(6)	PR institutions (1%)	0.0479	0.0915	0.0612***	0.0576***	0.1406***	0.09402***	0.0881***	1	-	-	-	-	-	-	-	-	-	-	-	-	-
(7)	PS institutions (1%)	0.0075	0.0213	-0.0002	0.0073	0.0285***	0.1028***	0.09888***	0.1035***	1	-	-	-	-	-	-	-	-	-	-	-	-
(8)	PR institutions (5%)	0.0094	0.0368	0.0175*	-0.0143	0.0452***	0.5713***	0.0718***	0.07025***	0.0827***	1	-	-	-	-	-	-	-	-	-	-	-
(9)	PS institutions (5%)	0.0021	0.0153	-0.0102	-0.0311***	-0.0071	0.0072	0.07418***	0.0180**	0.07548***	0.0332***	1	-	-	-	-	-	-	-	-	-	-
(10)	Firm size	7.591	1.252	-0.067***	0.2516***	0.1679***	0.1367***	0.0665***	0.0422***	0.0476***	-0.043***	0.0095	1	-	-	-	-	-	-	-	-	-
(11)	Firm age	15.56	5.030	-0.0268***	0.0263***	-0.1318***	-0.1263***	-0.0101	-0.1569***	-0.0135	-0.1319***	-0.0052	0.0778***	1	-	-	-	-	-	-	-	-
(12)	Leverage	0.0332	0.0594	-0.1934***	-0.0360***	0.0397***	0.0094	-0.0040	-0.0071	-0.0104	-0.0225**	-0.0043	0.2142***	0.0128	1	-	-	-	-	-	-	-
(13)	Profitability	0.0686	0.152	0.1200***	0.1347***	0.0847***	0.1367***	0.0413***	0.0872***	0.0341***	0.0274***	-0.00920	0.1002***	-0.0485***	-0.0166*	1	-	-	-	-	-	-
(14)	Growth	0.152	0.399	0.0215**	-0.0110	0.0232**	0.1620***	0.0268***	0.1502***	0.0274***	0.0838***	0.0176*	0.0413***	-0.0390***	0.0570***	-0.00400	1	-	-	-	-	-
(15)	PPE	0.252	0.152	-0.1682***	-0.0952***	-0.0248***	-0.1099***	-0.0382***	-0.0993***	-0.0414***	-0.0735***	-0.00380	0.2276***	0.0250***	0.3333***	-0.1014***	-0.0372***	1	-	-	-	-
(16)	SOE	0.389	0.487	-0.1338***	0.0160*	0.0878***	-0.0101	0.0065	-0.0353***	-0.0074	-0.0606***	0.0124	0.3151***	0.0510***	0.2153***	-0.0679***	-0.0199**	0.2018***	1	-	-	-
(17)	Board size	2.266	0.236	-0.0396***	0.0650***	0.0083	-0.0069	-0.0090	-0.0347***	-0.0154*	-0.0425***	-0.0053	0.2158***	0.0838***	0.0772***	-0.0260***	0.0146	0.0815***	0.2023***	1	-	-
(18)	HHI	0.090	0.0790	-0.0909***	-0.0734***	-0.0002	-0.0266***	0.0138	-0.0162*	0.0136	0.0074	0.0029	0.0807***	-0.0303***	0.0163*	-0.0103	0.0078	0.0089	0.0080	-0.0055	1	-
(19)	Market development	7.342	1.756	0.2300***	0.1896***	-0.0383***	-0.0271***	-0.0133	-0.0383***	-0.0124	-0.0192**	-0.0376***	-0.0659***	0.1256***	-0.1958***	0.0694***	-0.0346***	-0.1547***	-0.2915***	-0.0487***	-0.0394***	1

Note: This table reports the names of variables included in this study along with the descriptive statistics and correlation matrices. Innovation input illustrates R&D intensity. Pressure-resistance institution is an independent variable and illustrates PR institutional investors. Pressure-sensitive institution is also an independent variable and illustrates PS institutional investors. While Innovation performance (IP), illustrates the dependent variable of the study, that is, innovation performance. The terms in parentheses with the dependent variables such as (IPC) and (IP) refers to invention patents citation counts and invention patents simultaneously.

PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl-Hirschman Index.

*, $p < 0.1$; **, $p < 0.05$; ***, $p < 0.01$.

results, it was decided that the Fixed-Effect Model is appropriate. To overcome the possible simultaneity bias, all the independent variables have been lagged by 1 year, excluding the dummy variables (Piperopoulos et al., 2018). Following Rong et al. (2017), we used the log of one plus invention citation counts as the exploratory variables. Specifically, to overcome possible endogeneity produced by unobserved variables, we used year fixed-effect and industry fixed-effect in our models.

Results

Main results

Table 2 presents the correlation analysis and descriptive statistics for the variables. The table shows that all the correlations are reasonably low. These correlation coefficients suggest that multicollinearity is not a cause of serious concern. We also mean-centre the variables before generating those interaction terms, except for dummy variables, to alleviate the problem of multicollinearity.

Table 3 presents the regression of R&D intensity using a sample from 2007 to 2015. In this analysis, we have used three samples to see independent variables' influence across different samples. In Table 3, there are three models: model (1) comprises both the independent variables (PR institutions and PS institutions) and control variables for the entire sample (including both kinds of enterprises SOEs and non-SOEs). While model (2) investigates the effects of the same variables in a sample consisted of only SOEs and, model (3) is based on only non-SOEs.

Table 3, model (1) comprises the main continuous explanatory variables (PR and PS institutions) and control variables. Pressure-sensitive institutional investors' coefficient is negative

and significant at a 1% level of significance, thus lending support to H1 that predicts a negative relationship between PS institutional investors and R&D intensity. Nonetheless, PR institutional investors' coefficient is positive and significant, lending support to H2, which predicts a positive relationship between PR institutional investors and R&D intensity.

In model (2), the coefficients PR institutions are positive and significant at a 1% level of significance, which predicts that PR institutional investors are more positively related to R&D intensity in SOEs than non-SOEs. In model (3), PS institutional investors' coefficient is negative and significant at a 5% level of significance, which predicts that PS institutional investors are more negatively related to R&D intensity in non-SOEs than SOEs.

Table 4 presents the regression of innovation performance using a sample from 2007 to 2015. In this analysis, we have used three samples to see the influence of independent variables across these different samples.

In models 1–3, PR institutional investors' coefficient having less than 1% ownership is positive and significant at a 1% level. However, the PS institutional investors having the same ownership of less than 1% is also positive but insignificant, thus lending support to H3 which, predicts that PR institutional investors are more positively related to innovation performance than PS institutional investors.

In models 4–6, PR institutional investors' coefficient, this time having at least 1% ownership, is positive and significant at 1% level. While the PS institutional investors having the same ownership of at least 1% is positive and insignificant, this predicts that PR institutional investors are more positively related to innovation performance than PS institutional

TABLE 3: The institutional investors and innovation input (research and development intensity).

Models	(1)		(2)		(3)	
	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics
Pressure-resistance ownership (at least 1%)	0.0022*	1.67	0.0074***	2.91	0.0003	0.19
Pressure-sensitive ownership (at least 1%)	-0.0156***	-2.73	-0.0122	-1.19	-0.0154**	-0.982.29
Firm size	0.0004**	2.18	0.0009**	2.57	0.0003	0.98
Firm age	0.0010***	9.70	0.0015***	9.25	0.0004***	3.11
Leverage	-0.0067**	-2.36	-0.0017	-0.42	-0.0109***	-2.71
Profitability	0.0013*	1.72	0.0023*	1.88	0.0009	0.87
Growth	0.0006**	2.22	0.0007	1.49	0.0011***	2.91
PPE	-0.0012	-0.83	-0.0003	-0.14	-0.0003	-0.18
Board size	-0.0000	-0.07	-0.0010	-0.87	0.0007	0.82
SOE	0.0004	0.39	-	-	-	-
HHI	0.0105***	2.85	0.0087	1.15	0.0059	1.44
Market development	0.0001	0.16	0.0001	0.15	0.0005	1.07
Constants	0.0004	0.06	-0.0037	-0.66	0.0108	1.32
Year dummies	Yes	-	Yes	-	Yes	-
Industry dummies	Yes	-	Yes	-	Yes	-
Firm fixed effect	Yes	-	Yes	-	Yes	-
<i>N</i>	8670	-	3272	-	5398	-
<i>F</i>	26.7332	-	24.6757	-	10.1860	-
<i>R</i> ²	0.1150	-	0.1863	-	0.0717	-

PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl–Hirschman Index.

*, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.01$.

TABLE 4: The institutional investors and innovation performance (citation of invention patents).

Models	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		
	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	
PR Ownership (Less than 1%)	0.5316***	5.01	0.5405***	2.63	0.5260***	4.31	-	-	-	-	-	-	-	-	-	-	-	-	-
PS Ownership (less than 1%)	0.2380	0.43	-0.6995	-0.66	0.7282	1.14	-	-	-	-	-	-	-	-	-	-	-	-	-
PR Ownership (1%)	-	-	-	-	-	-	0.5568***	4.33	0.5506**	2.10	0.5766***	3.98	-	-	-	-	-	-	-
PS Ownership (1%)	-	-	-	-	-	-	0.3884	0.69	-0.4081	-0.38	0.8449	1.30	-	-	-	-	-	-	-
PR Ownership (5%)	-	-	-	-	-	-	-	-	-	-	-	-	0.5310*	1.91	0.3916	0.57	0.6719**	2.29	-
PS Ownership (5%)	-	-	-	-	-	-	-	-	-	-	-	-	-0.3587	-0.42	-1.8324	-1.27	0.8183	0.77	-
Constants	2.9117***	3.84	2.9046***	5.04	2.8640***	3.73	2.8777***	3.80	2.9143***	5.04	2.8153***	3.66	2.9235***	3.85	3.0591***	5.32	2.7995***	3.64	-
Year dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	-
Industry dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	-
Firm fixed effect	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	-
N	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-	-
F	52.7720	-	30.4642	-	33.1225	-	52.5615	-	30.3240	-	33.0495	-	51.9747	-	30.1954	-	32.5586	-	-
R ²	0.2208	-	0.2451	-	0.2145	-	0.2201	-	0.2442	-	0.2142	-	0.2182	-	0.2434	-	0.2117	-	-

Note: All control variables, year/industry dummies and firm fixed effects are included. Pressure-resistance Ownership illustrates PR institutional ownership and PS Ownership illustrates PS institutional ownership.

PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl-Hirschman Index.

*, $p < 0.10$, **, $p < 0.05$, ***, $p < 0.01$.

TABLE 5: The moderate effects of institutional investors (citation of invention patents).

Models	Citation of invention patents																		
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		
	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	
PR Ownership (0%)*	0.5279***	4.99	0.6682***	3.14	0.4317***	3.51	-	-	-	-	-	-	-	-	-	-	-	-	-
PS Ownership (0%)*	0.1566	0.28	-0.8268	-0.67	0.8625	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-
PR Ownership (0%)* R&D intensity	26.5824***	5.06	23.4218**	2.33	29.2768***	4.63	-	-	-	-	-	-	-	-	-	-	-	-	-
PS Ownership (0%)* R&D intensity	-51.4834	-1.38	-8.0281	-0.11	-1.0e+02**	-2.27	-	-	-	-	-	-	-	-	-	-	-	-	-
PR Ownership (1%)*	-	-	-	-	-	-	0.5793***	4.52	0.7891***	2.88	0.4740***	3.27	-	-	-	-	-	-	-
PS Ownership (1%)*	-	-	-	-	-	-	0.3344	0.58	-0.6590	-0.52	1.0261	1.58	-	-	-	-	-	-	-
PR Ownership (1%)* R&D intensity	-	-	-	-	-	-	44.7567***	6.56	39.6587***	2.99	49.7326***	6.09	-	-	-	-	-	-	-
PS Ownership (1%)* R&D intensity	-	-	-	-	-	-	-35.9796	-0.95	-13.3469	-0.18	-75.0661*	-1.65	-	-	-	-	-	-	-
PR Ownership (5%)*	-	-	-	-	-	-	-	-	-	-	-	-	0.5809**	2.10	0.8585	1.22	0.6258**	2.14	-
PS Ownership (5%)*	-	-	-	-	-	-	-	-	-	-	-	-	-0.2856	-0.30	-1.6555	-0.80	0.7947	0.74	-
PR Ownership (5%)* R&D intensity	-	-	-	-	-	-	-	-	-	-	-	-	105.9094***	6.04	102.3749***	3.11	106.7259***	5.15	-
PS Ownership (5%)* R&D intensity	-	-	-	-	-	-	-	-	-	-	-	-	9.3055	0.16	16.7678	0.14	-53.1755	-0.70	-
Constants	2.9380***	3.89	2.9240***	5.08	2.8583***	3.73	2.9003***	3.84	2.9489***	5.11	2.7571***	3.60	2.9275***	3.87	3.0490***	5.31	2.7506***	3.58	-
Year dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes
Industry dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes
Firm fixed effect	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes
N	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-	5172
F	50.8386	-	28.5254	-	32.1725	-	51.1997	-	28.5680	-	32.5481	-	50.4149	-	28.4729	-	31.6490	-	31.6490
R ²	0.2240	-	0.2468	-	0.2197	-	0.2252	-	0.2470	-	0.2217	-	0.2226	-	0.2464	-	0.2169	-	0.2169

Note: All control variables, year/industry dummies and firm fixed effects are included. Pressure-resistance illustrates PR in situational ownership and PS Ownership illustrates PS institutional ownership

PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl-Hirschman Index.

*, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.01$.

TABLE 6: The influence of institution investors (dummy variables) on research and development intensity.

Models	R&D intensity					
	(1)		(2)		(3)	
	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics
Dummy_PR Ownership (at least 1%)	0.0005**	2.16	0.0007	1.52	0.0006**	2.02
Dummy_PS Ownership (at least 1%)	-0.0007***	-2.77	-0.0003	-0.70	-0.0010***	-3.02
Constants	0.0005	0.08	-0.0024	-0.43	0.0106	1.30
Year dummies	Yes	-	Yes	-	Yes	-
Industry dummies	Yes	-	Yes	-	Yes	-
Firm fixed effect	Yes	-	Yes	-	Yes	-
N	8670	-	3272	-	5398	-
F	26.7855	-	24.3345	-	10.4072	-
R ²	0.1152	-	0.1842	-	0.0732	-

Note: All control variables, year/ industry dummies and firm fixed effects are included. Pressure-resistance Ownership illustrates PR institutional ownership and PS Ownership illustrates PS institutional ownership.

PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl–Hirschman Index.

*, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.01$.

investors. Categorising the sample into full (comprises of both SOEs and non-SOEs), SOEs and non-SOEs, also predicts that PR institutions are more positively related to innovation performance irrespective of sample selection. In other words, we can also interpret the results that PR institutions have a positive and significant impact on innovation performance irrespective of sample selection.

Table 5 presents PR and PS institutions' moderation effects on the relationship between R&D intensity and innovation performance. The sample categorisation and ownership of exploratory variables are just the same as in Table 4.

In model 1–3, the coefficient of the interaction term, *Pressure_res ownership (0%)* R&D intensity* is positive and significant at 1% level, at every category of sample selection (full, SOEs and non-SOEs), thus lending support to H4, which predicts that PR institutional investors positively moderates the relationship between R&D intensity and innovation performance. The interaction term's coefficient, *Pressure_sens ownership (0%)* R&D intensity*, is negative and significant at a 5% level of significance. Thus it lends its support to H5, which predicts that PS institutional investors negatively moderate the relationship between R&D intensity and innovation performance.

The preceding models, 4–6 and 7–9, also present the same results for PR and PS institutions' moderating role. We can interpret the results that PR institutions positively moderates the association between the R&D intensity and innovation performance irrespective of the ownership size (less than 1%, at least 1%, and at least 5%) and sample selection (full, SOEs and non-SOEs). While PS institution negatively moderates the association between R&D intensity and innovation performance only in non-SOEs, and their level of significant decrease as the ownership size increases from less than 1% to 5% ownership.

Robust check

Firstly, following the prior literature, we used institutional investors' dummies (*Dummy_Pressure_res ownership* and

Dummy_Pressure_sens ownership), and the value was equal to 1 if the PR and PS institutions have at least 1% ownership, otherwise zero. The dependent variable was R&D intensity. Results in Table 6 present that our findings are still robust though we used an alternative measure to represent institutional ownership.

Secondly, once again, we used dummies of institutional investors and the value was equal to 1 if institutional ownership was equal to less than 1%, at least 1% and at least 5%, respectively, otherwise zero. Results from Table 7 reveal that our findings are still robust, meaning that PR institutions have a pronounced positive effect on innovation performance than PS institutions, although we used an alternative measure as a proxy to represent financial institution's ownership.

Discussion and conclusion

This study intended to investigate the association between heterogenic institutional investors and corporate innovation, and highlighted the mechanism through which institutional investors affect the managerial actions that, in turn, affect corporate innovation. Berger et al. (2017) argued that the career concern model heavily depends on the model framework and claim that count data hurdle model,¹ neither the career concern model nor lazy managers hypothesis, satisfactorily explains the mechanism at work. Therefore, there is a great need to clarify the mechanism through which institutional investors affect corporate innovation.

Therefore, this study used a unique dataset of Chinese institutional investors from 2007 to 2015 of manufacturing firms listed on the Shenzhen Stock Exchange and Shanghai Stock Exchange. We found that PR institutions have a positive impact on R&D intensity, while PS institutions have a negative impact on R&D intensity. However, when we analysed the sample concerning SOEs and non-SOEs, then we found that PR institutions have a positive impact on R&D intensity only in SOEs, while they have no impact on non-SOEs. On the other hand, PS institutions have a negative impact on R&D intensity only in non-SOEs, while they have no impact in

¹ 'Hurdle models are two-part models with a binary part that models the decision to innovate at all, and a count part that models ongoing innovation, respectively'.

TABLE 7: The influence of institutional investors (Dummy variables) on innovation performance.

Models	Citation of invention patents																	
	(1)	(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		
	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	Statistics	Full sample	Statistics	SOE sample	Statistics	Non-SOE sample	
Dummy_PR Ownership (0%)	0.1019***	3.15	0.0025	0.04	0.1371***	3.58	-	-	-	-	-	-	-	-	-	-	-	-
Dummy_PS Ownership (0%)	-0.0181	-0.79	-0.0214	-0.52	-0.0226	-0.82	-	-	-	-	-	-	-	-	-	-	-	-
Dummy_PR Ownership (1%)	-	-	-	-	-	-	0.0658***	2.77	0.1071**	2.42	0.0413	1.49	-	-	-	-	-	-
Dummy_PS Ownership (1%)	-	-	-	-	-	-	0.0105	0.40	0.0139	0.29	0.0048	0.16	-	-	-	-	-	-
Dummy_PR Ownership (5%)	-	-	-	-	-	-	-	-	-	-	-	-	0.1018***	2.78	0.1664**	2.20	0.0859**	2.10
Dummy_PS Ownership (5%)	-	-	-	-	-	-	-	-	-	-	-	-	-0.0616	-0.81	-0.2813*	-1.85	0.0508	0.59
Constants	2.9213***	3.85	3.0689***	5.35	2.7924***	3.63	2.9644***	3.91	3.0214***	5.27	2.8510***	3.70	2.8981***	3.82	2.9699***	5.16	2.7916***	3.62
Year dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Industry dummies	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Firm fixed effect	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
N	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-	8181	-	3009	-	5172	-
F	52.2066	-	30.1105	-	32.8308	-	52.1355	-	30.4078	-	32.4201	-	52.1368	-	30.5253	-	32.5177	-
R ²	0.2190	-	0.2429	-	0.2130	-	0.2187	-	0.2447	-	0.2109	-	0.2187	-	0.2454	-	0.2114	-

Note: All control variables, year/industry dummies and firm fixed effects are included. Pressure-resistance Ownership illustrates PR institutional ownership and PS Ownership illustrates PS institutional ownership.

PR, pressure-resistant; PS, pressure-sensitive; PPE, Property, plant, and equipment; SOE, state-owned enterprises; HHI, Herfindahl-Hirschman Index.

*, $p < 0.10$; **, $p < 0.05$; ***, $p < 0.01$.

SOEs. Furthermore, we found that PR institutions are more positively associated with innovation performance than PS institutions. Additionally, we found that PR institutions positively moderate the association between R&D intensity and innovation performance both in SOEs and non-SOEs. While PS institutions negatively moderate the associations between the R&D intensity and innovation performance only in non-SOEs.

Practical implications

This research has numerous practical implications from a public policy standpoint. The prevalent conviction that institutions have a negative impact on corporate innovation (Porter, 1992), was negated by the study of (Kochhar & David, 1996). Nonetheless, our study using a heterogenic categorisation of PR institutions and PS institutions complement the study of Porter, by arguing that PS institutions have a negative impact on R&D intensity. In fact, our study highlighted the mechanism of business relations that affects institutional investors and resultantly corporate innovation.

Conspicuous investors such as Warren Buffet once endorsed a need to tax the institutional investors on gains provided that the stocks are held for less than 1 year to influence long-term investments (Lowenstein, 1988). However, in light of this study, we argue that there is no need for this kind of policy to influence long-term investments. Rather, there is a need to review the proxy guidelines and other regulations that help prevent institutions from affecting managers (Black, 1992).

Limitations and future research directions

This study has certain limitations that require careful consideration while interpreting the results. Firstly, this study is established on data from a single country. Although China is one of the most prominent transition economies, the ownership structure is entirely composite in China (Zhou et al., 2017). A transition economy, or in other words, the transitional economy, refers to an economy that changes from central planning to a market economy (Feige, 1994). Therefore, these findings cannot be generalised to other developed economies. Furthermore, cross-country analysis is required to increase the understanding of this phenomenon. Secondly, our investigation is confined to manufacturing industry-listed companies, and we have determined that industries vary in their regulations and standards. Thus, cross-industrial investigations are warranted to determine whether these outcomes are extendable to other industries or not.

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Competing interests

No conflict of interest exists in the submission of this manuscript, and all authors approve the manuscript for

publication. I would like to declare on behalf of my co-authors that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. All the authors listed have approved the manuscript that is enclosed.

Authors' contributions

S.T.A. was responsible for writing. Z.Y. was responsible for formal analysis, methodology, writing and correspondence. F.A. was responsible for writing, revision, editing the manuscripts. M.U., M.M.A. and A.K. revised and edited the manuscript.

Ethical considerations

This article followed all the ethical guidelines for a research project without direct contact with human or animal subjects.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available and are hand collected; but are available from the corresponding author on reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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