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Article

Institution-driven innovation in Guangdong firms: Moderating effects of in-house formal R&D and industrial environment turbulence

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Abstract

This article explores the moderating effects of in-house formal R&D and industrial environment turbulence on the relationship between institutional drivers, in terms of incentives and pressures, and firm innovation. Hypotheses were tested on a sample of manufacturing firms in Guangdong Province of China, where institutional changes and governmental policies play prominent roles in shaping innovation. Results show a positive main effect of institutional incentives, but an insignificant main effect of institutional pressures. In-house formal R&D and industrial turbulence negatively moderate the institutional incentives–innovations relationship, yet positively moderate the institutional pressures–innovations relationship. This study links the innovation systems literature with the institution-based view and deepens the understanding of the joint forces of institutional transitions, industrial changes, and resource heterogeneity in shaping innovation. The findings also inform managers and policymakers in institutional transition environments to better manage institutional drivers of innovation by considering firm- and industry-specific characteristics.

Key words: innovation; institutions; regulations; innovation policy; China

1. Introduction

National and local governments in emerging economies, such as China, play significant and direct roles in promoting innovation through institutional, regulatory, and policy changes. For example, China's national innovation system has been undergoing fundamental changes. This includes the shifted policy focus towards 'indigenous innovation' and 'innovation-driven development' (Liu et al. 2017; Li and Georghiou 2016) and the strengthened intellectual property rights (IPR) (Peng et al. 2017), standards (Mangelsdorf 2011), and environmental protection regulations (Zhao and Sun 2016). Under this dynamic institutional environment, a firm's innovation is inevitably affected by pervasive institutional conditions and transitions.

The innovation systems approach emphasises the central roles of institutions in setting the framework conditions for innovation (Edquist 2004). Institutions offer incentives and exert pressures, analogous to the 'carrots' and 'sticks', that drive innovation activities in different ways (Edquist and Johnson 1997). Following these insights, previous empirical studies have extensively investigated the impact on innovation from institutions in the form of standards (Blind 2016a), environmental protection and other regulations (Stewart 2011; Blind 2016b), IPR legislation (Encaoua et al. 2006), and innovation policy measures (Edler et al. 2016). The findings of these studies, however, have provided a rather inconsistent picture. For example, environmental protection regulations have been known to divert resources and constrain innovation; however, recent studies have found a positive link between stringent regulations and innovation, supporting the Porter Hypothesis (Ambec et al. 2013). Government support may act as a double-edged sword—on the one hand, it increases innovation intensity, but on the other hand it has several negative effects: it distracts attention from commercialisation (Shu et al. 2015), crowds out private R&D investments (Cunningham et al. 2016), and leads to lower quality and lower market value of patented innovations (Long and Wang 2019).

In response to this on-going debate, this study draws from the institution-based view (Peng et al. 2009), which contends that organisational strategy is shaped by the joint forces of institutional transitions, industrial changes, and resource heterogeneity, in order to explore the resource and industry conditions of the institutions' impact on innovation. Specifically, we focus on in-house formal R&D, because it exerts significant impacts on strategic innovation decisions (Engelen and Brettel 2012; Teirlinck and Spithoven 2013), and industrial environment turbulence, which reflects the uncertainty and rate of change in a task environment, caused by variations in technology and customer preferences (Calantone et al. 2003; Danneels and Sethi 2011). We will investigate how these two resource and industry contingency factors affect the institution–innovation relationship.

To achieve these objectives, a government-supported survey was conducted in Qingxi Town, a famous specialised town located centrally in the Pearl River Delta (PRD) of Guangdong Province, where institutional changes and governmental policies play prominent roles in shaping firm innovation (Barbieri et al. 2012). A negative binomial model and moderated multiple regression were adopted to test the hypotheses. Results show a positive main effect of institutional incentives, but an insignificant main effect of institutional pressures. Nonetheless, the effect of institutional incentives on innovations is negatively moderated by in-house formal R&D and industrial turbulence, whereas institutional pressures–innovations relationship is positively moderated. In this regard, this study links the innovation systems literature (Edquist 2006) with the institution-based view (Peng et al. 2009) and helps to better clarify the ambivalent findings of institution's impact on innovation in previous empirical studies that largely ignored these contingency factors.

The next section develops the theoretical framework and the hypotheses for the study. The following two sections describe the research methods and present the results. The last section provides a discussion and concluding remarks.

2. Theory and hypotheses

Institutions regulate the interactions within and across organisations in innovation creation and diffusion within an innovation system (Edquist and Johnson 1997). Among the wide range of institutions in general, this study is interested in institutions that directly affect the innovation process. Specifically, the focus is on formal institutions in the core innovation regulation areas (Borrás and Edquist 2014) that are closely related to technological innovations and new products, including IPR legislation, technical and product standards, and environmental protection regulations dealing with the negative externalities of the products to the natural environment. In addition, this study also considers the innovation policies that directly intervene in the generation and diffusion of innovations. These encompass both supply-side policies that can increase input to a firm's innovation (including public funding and subsidies) and demand-side policies that stimulate market demands for innovative products (including public procurement, support for private demand, pre-commercial procurement, etc.) (Edler and Fagerberg 2017; Boon and Edler 2018).

Different types of institutions and regulations have different objectives and differ in the way they affect firms' innovation. However, they all generate incentives and pressures to regulate firm innovation (Edquist and Johnson 1997; Peng et al. 2009). On the one hand, command-and-control instruments, such as directives of environmental protection, safety and health standards, and IPR enforcement laws, pose barriers (Zhu et al. 2012) and create pressures (Peng and Chen 2011) in firm innovation by means of imposed mandatory requirements and compliance costs. On the other hand, market-based instruments in the forms of funding, subsidies, marketable permits, and IPR grants and certifications provide incentives that steer a firm's innovation towards desired policy, societal, or environmental protection goals (Stewart 2011; Blind 2016b). The institution-based view further suggests that firm strategy is shaped by the joint forces of institutions, industrial conditions, and internal resources (Peng et al. 2009). Meanwhile, recent studies showed that institutions' impact on innovation is also dependent on a firm's accumulated competences and R&D components and uncertainty in the market and technology (Zúñiga-Vicente et al. 2014; Costantini et al. 2015; Shen, Feng and Zhang 2016; Blind et al. 2017).

Based on these insights, this study will probe into how the effects of institutional incentives and pressures on innovation vary with resource and industry conditions. Specifically, we focus on in-house formal R&D that exerts significant impacts on strategic innovation decisions (Engelen and Brettel 2012; Teirlinck and Spithoven 2013) and industrial environment turbulence that reflects the uncertainty and rate of change in the task environment (Calantone et al. 2003; Danneels and Sethi 2011). To do so, a simple conceptual framework is constructed combining the innovation systems literature (Edquist 2006) and the institution-based view (Peng et al. 2009) as illustrated in Figure 1. In the following, we will develop the hypotheses based on this model.

2.1 Institutional drivers of innovation

Institutional incentives in firm innovation come from a firm's perception of the anticipated economic incentives or potential opportunities in the institutional environment. They are essential in helping firms overcome market failures by providing motivations to invest in innovations inherently associated with uncertainty (Edler and Fagerberg 2017). A firm's incentive to innovate depends on a number of factors, including the availability of funding to move from innovative ideas to commercialisation, the ease of appropriation of the innovations, the potential market size of innovative products, and the risks and uncertainty of returns on innovation (Pelkmans and Renda 2014). Different institutions and regulations affect these factors and generate innovation incentives in different ways.

Institutional incentives increase the availability of resources for both innovation creation and diffusion (Mueller et al. 2013). Supply-side policy instruments, such as R&D funding, subsidies, and fiscal incentives, provide resources and induce private investments in innovation development directly. Demand-side instruments motivate users to commit resources to innovative products through public procurement and private demand support policies (e.g. tax incentives and subsidies) (Edler et al. 2016; Boon and Edler 2018). These technology-push and demand-pull instruments combine together in a policy mix that creates the incentive structure driving innovation dynamics (Costantini et al. 2015). As a result, increased availability of resources on both the supply and demand sides offers stable and predictable conditions for long-run innovation investments.

Institutions also provide essential information that reduces risks associated with innovation opportunities (Edquist and Johnson 1997; Young et al. 2018). Policy goals and priority areas articulated in technology foresight, promotion policies (Edler et al. 2016), and environmental protection regulations (Stewart 2011; Blind 2016b) can motivate firms to focus their limited resources on viable innovation opportunities. Demand-side measures (Boon and Edler 2018) and technical standards (Blind 2016a) can also reduce information asymmetries between innovators and users and facilitate their

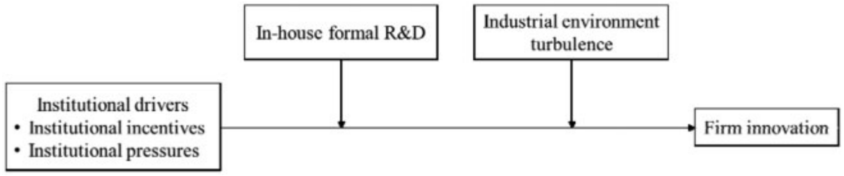

Figure 1. The conceptual model.

decisions concerning innovation creation and adoption. Meanwhile, IPR legislation imposes a legal exclusivity on the implementation of proprietary technology; thus, they secure returns on innovation and motivate ex-ante investment in R&D (Encaoua et al. 2006). These institutions reduce risks in innovation opportunities and provide stability (Young et al. 2018) that increases the possibility of innovation success.

Nonetheless, most institutional incentives are aimed at social innovations (Stewart 2011) towards policy or societal goals that often ignore market demand conditions (Boon and Edler 2018). Social innovations oriented towards creating social benefits may contradict a firm's private investments in market innovations for capturing commercial profits (Stewart 2011). For example, public support and regulations on environmental protection may have a positive impact on social innovation by spurring the development of cleaner technologies, yet at the same time, may have a negative impact on market innovation by diverting resources away from more profitable innovations. In addition, studies on eco-innovation suggest that the growth of markets associated with demand-pull policies may create disincentives for the development of non-incremental innovations and increase the risks of technological lock-ins (Costantini et al. 2015). Monetary public R&D incentives were also found to have mixed crowding-in or crowding-out effects on private R&D spending (David et al. 2000; Zúñiga-Vicente et al. 2014; Cunningham et al. 2016). Moreover, the halo-effect, which allows firms that were subsidised in the past to be more successful under a new programme (Feldman and Kelley 2006), may lead to a stronger crowding-out effect for more frequent recipients of public subsidies (Zúñiga-Vicente et al. 2014). As a result, a firm with continuous successes in receiving institutional incentives and government funding will have significantly less motivation to take the risks of private investments in divergent market directions. Therefore, institutional incentives can increase a firm's R&D and innovation, whilst at the same time creating resource tension by crowding-out private investments in innovation. Consequently, the net impact depends on the difference of these two opposing effects.

Besides providing incentives, institutions also generate pressures of legitimacy and burdens of compliance by imposing regulatory constraints and requirements. Stringent regulations affect the level of innovativeness and related burdens required for compliance (Stewart 2011; Pelkmans and Renda 2014). The higher the regulatory stringency, the greater the degree of required innovativeness and associated compliance burdens and costs and thus, the larger the institutional pressures perceived by the firm. Previous studies have indicated that high pressures from stringent institutions and regulations have two competing impacts on firm innovation (Stewart 2011; Blind 2016b): (1) blocking innovation by diverting resources and limiting variations; and (2) inducing compliance innovations or circumventive innovations.

A firm's intense efforts to address institutional constraints or compliance requirements will divert its limited attention and resources away from more productive innovation activities (Stewart 2011), hence reducing the availability of resources for innovation (Mueller et al. 2013). For example, a firm may be forced to increase its expenses to deal with technical barriers, such as performance benchmarks set by standards or environmental protection regulations (Mangelsdorf 2011; Stewart 2011) or it may have greater transaction costs to acquire external patent licences or other proprietary technological knowledge to avoid infringement of IPR laws and regulations (Arora and Gambardella 2010). Moreover, stringent rules and constraints can restrict the flexibility of entrepreneurial decisions in innovation (Young et al. 2018). Standards, environmental protection regulations, and IPR restrictions can hinder innovation by limiting the technical variations that could be otherwise combined to create innovations (Stewart 2011). Consequently, a firm's innovation efforts may also be locked in an established technological trajectory of pre-existing standards and regulations (Blind 2016a).

In contrast, the famous Porter Hypothesis posits that pressures from stringent regulations can trigger greater innovation and more fundamental solutions with larger innovation offsets (Porter and van der Linde 1995). A review of two decades of research into this hypothesis has demonstrated that the empirical evidence largely supports a positive link between stringent environmental protection regulations and innovation (Ambec et al. 2013). Although a firm manager may have the behavioural inclination to go after 'low-hanging fruits' and may tend to postpone innovation investments with uncertain long-term returns, the stringent requirements of compliance innovations can force the manager to overcome the bias (Ambec et al. 2013). When facing strict and disruptive regulatory requirements, a firm is forced to further increase its efforts to achieve compliance or circumventive innovations, causing more fundamental and radical changes (Stewart 2011). In the face of stringent IPR legislation pertaining to high licence fees and transaction costs, firms may also be pressured to penetrate through or circumvent existing patent thickets in inventive ways (Shapiro 2001). Hence, greater institutional pressures incurred by stringent regulations will spur more innovative and fundamental technological changes. It appears that institutional pressures also do not have a clear-cut one-directional effect on firm innovation. Again, the overall effect depends on the relative magnitude of the competing innovation-inducing and innovation-blocking impacts.

The above discussion indicates that institutional incentives and pressures do not have a conclusive positive or negative effect on firm innovation. However, recent studies have indicated that institutions, regulations, and public policies may affect firm innovation differently, depending on the contexts and factors under scrutiny, such as firms' accumulated competences and R&D components and uncertainty in the market and technology (Zúñiga-Vicente et al. 2014; Costantini et al. 2015; Shen, Feng and Zhang 2016; Blind et al. 2017). This aligns with the institution-based view (Peng et al. 2009), which also emphasises the importance of resource and industry conditions for an institution's impact on organisational strategy. In the next section, we will consequently probe into how the effects of institutional drivers in terms of incentives and pressures on firm innovation change under different conditions of in-house formal R&D and industrial environment turbulence.

2.2 The moderating effects of in-house formal R&D

In-house R&D serves as an important source of dynamic capability that enables a firm to develop innovations internally (Helfat 1997) or absorb new technologies from the outside (Cohen and Levinthal 1990). In this study, we distinguish firms that undertake in-house formal R&D in a continual manner formally organised by an R&D department, from those which only conduct occasional internal R&D organised on an ad hoc basis, or even perform no internal R&D at all, relying entirely on external R&D support.

Because knowledge generated by R&D is subject to spillovers, forgetting, and obsolescence (Cuervo-Cazurra and Un 2010), a firm must have a continuous stream of formal R&D investment to prevent imitation whilst maintaining and renewing its capabilities over time. In addition, a structured R&D department with a dedicated R&D staff helps to transform individual knowledge into organisational capabilities, avoiding knowledge losses due to changes in individuals' tasks or positions (Lam 2010). Thus, in-house formal R&D is associated with a higher internal innovation investment and a greater amount of accumulated knowledge and capabilities. Nonetheless, previous empirical studies have indicated that government support and incentives, such as R&D subsidies, are more effective for smaller firms with limited innovation resources and capabilities (Cunningham et al. 2016). It follows that the innovation-increasing effect of institutional incentives would be weaker for firms who have already invested a great amount in formal and continual R&D than for those who have not, due to the decreasing return of R&D investment.

Moreover, social innovations driven by institutional incentives and market innovations demanded by customers may require very different knowledge and capabilities (Stewart 2011). Due to a firm's resource dependence on market and customers (Pfeffer and Salancik 1978), an R&D department derives its power in an organisation through its contribution of creative and innovative solutions that cater to market needs (Engelen and Brettel 2012). It is consequently more inclined to devote resources towards market innovations than social innovations. When government institutions incentivise the diversion of resources to social innovations (Stewart 2011), an R&D department's capability to produce market innovations would be hampered and its power in the organisation would be undermined (Engelen and Brettel 2012). Hence, it may use its influence to thwart strategic decisions (Teirlinck and Spithoven 2013) concerning the pursuit of institutional incentives. Therefore, the existence of a formal R&D department will intensify the resource tension between market innovations demanded by customers and social innovations driven by institutional incentives. This leads to the following hypothesis:

> *Hypothesis 1a: A firm's in-house formal R&D negatively moderates the effect of institutional incentives on innovations, such that it decreases the innovation-increasing effect and increases the resource tension caused by institutional incentives.*

Compliance to regulations and standards is essential for the legitimacy and acceptance of a firm's products in the market (Stewart 2011; Blind 2016a), a lack of which may eventually endanger its survival (e.g. Peng and Chen 2011). In this regard, firms may be forced to divert limited resource to address compliance requirements. A firm with a continual stream of in-house formal R&D investment can better shoulder the pressures of legitimacy and have less resource tension than one that only invests in R&D on an ad hoc basis or performs no internal R&D at all. An established R&D department can also facilitate the accumulation of experience and knowledge (Cuervo-Cazurra and Un 2010) related to compliance solutions and can increase the productivity in creating compliance innovations. Such experience and knowledge would suffer from forgetting or knowledge loss if the firm only performs ad hoc R&D or purely relies on external compliance supports.

Moreover, addressing both customer demands and compliance requirements would increase the complexity and uncertainty of technology solutions (Stewart 2011). In such cases, a formal R&D department could better integrate and coordinate knowledge and capabilities (Cuervo-Cazurra and Un 2010) across internal sub-units to produce successful innovations. Structured processes enabled by a formal R&D department could mitigate the increased level of risk and allow for better cross-functional integration and coordination, which is required to develop complex technological solutions (Holahan et al. 2014). Formalised R&D practices, such as senior management involvement or full-time leadership and champions, could ensure the proper attention, resources, advocacy, and protection to serve the complex and often risky innovations that seek to combine customer needs and compliance requirements.

In addition, compared with pure market innovations, compliance innovations demand higher coordination efforts that go well beyond internal sub-units—to involve intensive interactions with external governmental agencies, regulatory entities, and standard-setting bodies (Stewart 2011). An R&D department's formalised processes could foster structured information and knowledge sharing with external partners; this in turn would integrate work activities and enhances goal alignment across organisational boundaries (Schepers et al. 2019). Systematic rules and procedures also act as a frame of reference that limits deviation from regulatory requirements; thus, these rules also promote compliance solutions through coordinated inter-organisational efforts. Hence, the existence of a formal R&D department can mitigate resource tension, while at the same time can increase productivity in producing compliance innovations driven by institutional pressures. In sum, we posit that:

> *Hypothesis 1b: A firm's in-house formal R&D positively moderates the effect of institutional pressures on innovations, such that it increases the innovation-inducing effect and decreases the resource tension caused by institutional pressures.*

2.3 The moderating effects of industrial environment turbulence

Industrial environment turbulence refers to the rate and uncertainty of change in a firm's task environment caused by variations in technology and customer preferences (Calantone et al. 2003). Fast and unpredictable changes in technology and customer needs may open up new technological trajectories or create new market niches, while at the same time they may also pose threats of rendering old technologies, products, resources, and competencies obsolete (Danneels and Sethi 2011). This impels a firm to invest heavily on new technological and market directions to rapidly develop innovative products in order to keep pace and stay competitive in the market.

As discussed above, a firm's perceived institutional incentives steer it towards social innovations to meet policy or societal goals (Stewart 2011). Social innovations are intrinsically different from and even contradict market innovations demanded by rapid changes in technology or customer needs in a firm's industry. They may require completely different resources and capabilities and stretch managerial efforts and attention in divergent directions. In a turbulent industry, firms have to increase their market orientation and devote a large amount of resources to respond to fast changes in a timely manner (Calantone et al. 2003). Thus, R&D staff are occupied in intense efforts to address the fast-changing customer preferences or technologies in the market and are forced to give less resources and attention to government-supported social innovation projects. Hence, resource tension between social and market innovations becomes more severe under turbulent industrial conditions.

Moreover, although institutional incentives can help to increase a firm's innovation intensity, the attempt to simultaneously combine social goals incentivised by institutional support (Stewart 2011) and market objectives pressed by industrial dynamism (Calantone et al. 2003) adds to the difficulty of technological problems. This, in turn, requires more complex solutions that demand higher capabilities and longer development times. A firm may end up with 'dud' inventions that are not consistent with its customers' needs; this will affect the firm's overall innovation performance (Stewart 2011). Thus, in turbulent industries, the innovation-increasing effect of institutional incentives towards social innovations is counteracted by the imperatives of market innovations. This leads to the following hypothesis:

Hypothesis 2a: The level of turbulence in a firm's industry negatively moderates the effect of institutional incentives on innovations, such that it increases the resource tension and decreases the innovation-increasing effect caused by institutional incentives.

Stringent institutional rules in standards, regulations, and IPR legislation limit a firm's technological choices and constrain its innovation (Stewart 2011). Nonetheless, turbulent changes in technology and customer needs present firms with potential innovation opportunities in terms of new market segments and new technological trajectories (Danneels and Sethi 2011). These opportunities open up avenues for inventive compliance innovations or circumventive innovations that can be less confined by or even can escape from regulatory restrictions (Stewart 2011). Thus, pressures to meet compliance requirements are less likely to constrain innovation for firms in turbulent industries that are rich in innovation opportunities than in stable industries with little changes in technology or customer needs.

Although the imposed institutional rules of legitimacy and compliance may restrict innovation to a limited range of technological choices, they also reduce uncertainty and provide guidance to innovation (Edquist and Johnson 1997; Young et al. 2018). Stringent institutional constraints that reduce variety may stifle innovation in stable and mature industries where innovation opportunities are already depleted. In turbulent industries of emerging technologies or markets, however, institutions' mandates that reduce uncertainty could be pivotal in the pursuit of innovative opportunities (Young et al. 2018). For example, compliance requirements in standards and environmental protection regulations could provide guidance to and focus a firm's R&D efforts towards viable directions in emerging technological fields; they could also help to create legitimacy for new technologies and increase customer acceptance by demonstrating that products have the desired functionality, performance, quality, and acceptable risks for health, safety, and the natural environment (Blind 2016a). Hence, in industries undergoing turbulent changes in emerging technologies and markets, the pressuring regulatory rules will exhibit greater innovation-inducing effect by reducing uncertainty on both producer and customer sides.

Hypothesis 2b: The level of turbulence in a firm's industry positively moderates the effect of institutional pressures on innovations, such that it decreases the innovation-constraining effect and increases the innovation-inducing effect caused by institutional pressures.

3. Empirical analysis

3.1 Data and sample

Data to test the hypotheses were collected from a government-supported survey on local firms' innovation in Qingxi Town, centrally located at the PRD of Guangdong Province in China. The opening-up and institutional transition of the Chinese economy since the 1980s started in Guangdong, specifically in the PRD, where the state and local governments experimented with institutional, regulatory, and policy measures towards market-oriented reforms (Barbieri et al. 2012). Beyond the overall turbulent changes in the national institutional framework, the policy efforts of the local Guangdong provincial government also played crucial roles in shaping the local industrial development, most prominently the 'Specialised Town Programme', which was launched in 2000. Qingxi is a typical specialised town that started its industrial development with export-oriented labour-intensive products in the 1980s until it was encouraged by the provincial government to promote photoelectric and communication products and other high-technology products since the late 1990s. The prominent roles of institutional changes and policy instruments in shaping firm innovation in specialised towns (Barbieri et al. 2012) make Qingxi an ideal context to examine the research questions of this study.

A full list of the town's 293 manufacturing firms with annual total sales equal to or greater than RMB 20 million (USD 3.23 million) in 2014 was obtained from the local Science, Technology & Innovation Service Centre (STISC). Questionnaires were sent by the STISC via e-mail to all of the firms on the list. We requested that the respondent be the firm's General Manager/CEO or the CTO/Director of the R&D department. STISC then collected the completed questionnaires in article form. By the end of January 2016, a total of 219 questionnaires were returned. Among them, fifty-three were excluded because of missing data. In the end, 166 valid responses were counted, resulting in a response rate of 56.7 per cent. Table 1 shows the main characteristics of the firms in the sample.

3.2 Variables and measures

3.2.1 Dependent variable

In this study, we intend to explore the roles of formal institutions (including IPR, technical and product standards, environmental protection regulations, innovation policies) in the core innovation regulation areas (Borrás and Edquist 2014) in driving the development of technological innovations and new products. We also focus on product innovation rather than process innovation, because it is more closely related to IPR and technical and product standards. In this regard, we use the number of new product introductions to measure a firm's product innovations. Product innovation is defined according to the Community Innovation Survey in Europe (CIS 2014) as the market introduction of a product that is new or significantly improved with respect to its characteristics or intended use. This excludes the simple resale of new goods purchased from other companies and changes of a solely aesthetic nature. Product innovations must be new to the firm, but they do not need to be new to the market. We then requested the respondent to report the number of product innovations introduced by the company in the last three

Table 1. Main characteristics of the study sample.

Characteristics	Per cent
Number of employees	
<50	1.2
51–300	51.2
301–500	21.1
501–2,000	23.5
2,000+	3.0
Sales revenue (in million RMB and million USD in brackets)	
20–50 (3.23–8.08)	30.1
51–200 (8.24–32.31)	52.4
201–1,000 (32.47–161.55)	14.5
1,000+ (161.55+)	3.0
Firm age (years)	
3–5	27.7
6–10	27.1
11–15	25.3
16 +	19.9
Industry affiliation	
Computers, communication, and other electronics equipment	32.7
Electrical machinery and equipment	13.3
General and special purpose equipment	12.7
Metal products	9.6
Chemical products	9.0
Others manufacturing	22.7
R&D personnel intensity	
0 per cent	29.5
0–10 per cent	49.4
11–20 per cent	13.9
21–30 per cent	2.4
≥31 per cent	4.8

years, in order to capture a more stationery response of the uncertain innovation processes (CIS 2014). It is assumed that the number of new products introduced as a result of a firm's product launch schedule/strategy is related to the institutional drivers, industry turbulence, and internal resource heterogeneity during the period.

3.2.2 Independent variables

Well-developed scales of perceived institutional incentives and pressures in firm innovation are not available in the literature. The scales in this study were therefore developed by relying on previous-related empirical studies on institutional and government support for innovation (Li and Atuahene-Gima 2001; Shu et al. 2016) and the measurement of different types of formal institutions (Blind 2012; Garrido et al. 2014; Deng and Zhang 2018). Two three-item scales were developed for institutional incentives and pressure constructs, respectively, as shown in Table 2. Based on these items, the respondent was asked to indicate on a seven-point Likert-type scale the degree of perceived institutional incentives and pressures in the firm's innovation in the last three years.

Since the constructs and scales were new, a number of analyses were conducted to test their validity and reliability. First, an exploratory factor analysis (EFA) was carried out to assess the underlying factor structures. A determinant of the correlation matrix close to zero (0.004), a highly significant chi-square in the Bartlett test of sphericity (890.371) and a Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy higher than 0.7 (0.81), supported the appropriateness of this analysis for the dataset. The EFA produced one factor with an eigenvalue greater than 1 and one factor very close to 1 (0.99), together explaining 87 per cent of the total variance. An orthogonal varimax rotation showed that all of the items were significantly loaded on the expected factors (ranging from 0.83 to 0.92), and no cross-loading was detected. Reliability analysis also indicated high internal consistency of both constructs, with Cronbach's alphas higher than 0.9, well above the threshold of 0.7. These results support the a priori theoretical assumptions of the factor structure.

Next, a confirmatory factor analysis (CFA) using structural equation modelling was carried out to assess the dimensionality, reliability, and validity of the reflective measures. The overall model fit of the two-factor model was $\chi^2 = 25.574$, with the d.f. = 8, $P < 0.0012$, root mean squared error of approximation (RMSEA) = 0.1150, comparative fit index (CFI) = 0.98, Tucker-Lewis index (TLI) = 0.96, and standardised root mean squared residual (SRMR) = 0.027. Sufficient goodness-of-fit is supported, according to the two-index combination rules suggested by Hu and Bentler (1999).

Furthermore, individual item reliability, composite reliability, and average variance extracted (AVE; Fornell and Larcker 1981) were also calculated. As shown by the results in Table 2, all of the individual item reliability values (ranging from 0.69 to 0.97) exceeded the recommended threshold of 0.5 and the composite reliability values (0.91 for *institutional incentives* and 0.94 for *institutional pressures*) were both well above the cut-off value of 0.7 (see Bagozzi and Yi 2012). The AVE values (0.77 for *institutional incentives* and 0.84 for *institutional pressures*) were also above the recommended lower limit of 0.5. Thus, the model achieved satisfactory reliability.

Additionally, satisfactory convergence (all factor loadings items related to the hypothesised latent variables, ranging from 0.83 to 0.98, are significant at the 0.01 level) and discriminant validity (the AVE value of each construct is significantly higher than the 0.428 shared variance between them) were shown for both constructs (see Bagozzi et al. 1991; Fornell and Larcker 1981). Discriminant validity was also satisfactory at the item level, with all items sharing more variance with their intended construct than with the other construct. Further inspection of the absolute standardised correlation between the two constructs (*institutional incentives* and *institutional pressures*) revealed that we can reject the hypothesis that the factors are perfectly correlated (Bagozzi and Yi 2012): the correlation (0.65) is significantly less than 1, and it has a 95 per cent confidence interval that does not include 1.

Lastly, a CFA was conducted for a one-factor model with all six items loaded on a single factor. The overall model fit of this one-factor model ($\chi^2 = 227.25$, with d.f. = 9, $P < 0.0001$, RMSEA = 0.3820, CFI = 0.76, TLI = 0.59, SRMR = 0.129) was much worse than that of the two-factor model, further supporting the appropriateness of the two-factor model. In sum, these tests confirmed the validity and reliability of the two constructs.

3.2.3 Moderating variables

The first moderator, *in-house formal R&D*, was captured as a binary variable of whether a firm had a full-staffed R&D department during the last three years. This measure is in line with previous studies (e.g. Flor and Oltra 2004; Escribano et al. 2009; Teirlinck and Spithoven, 2013). Note that *in-house formal R&D* is different from other indicators of internal R&D, such as R&D intensity or R&D expenditures. The existence of a formal R&D department with a dedicated full-time staff implies the formal allocation of resources and the continuity of innovation efforts (Flor and Oltra 2004; Cuervo-Cazurra and Un 2010), a formalised organisation and management of innovation activities (Teirlinck and Spithoven 2013), and cumulativeness

Table 2. Measurement scales for institutional incentives and pressures constructs.

Construct	Standardised factor loading	Cronbach's alpha	Individual item reliability	Composite reliability	Average variance extracted
Institutional incentives (Li and Atuahene-Gima 2001; Garrido et al. 2014; Shu et al. 2016)		0.91		0.91	0.77
We closely follow government promotional policies (such as Made in China 2025; Internet Plus) or advice from industrial associations and other official institutions on promising future directions (such as technology foresight or technology roadmaps) to decide on innovations	0.88		0.77		
We innovate to obtain government funding or prizes, financial and taxation subsidies, certifications and recognitions for public image	0.88		0.77		
We innovate to appropriate the high economic premium of the innovations secured by IP laws and regulations	0.87		0.76		
Institutional pressures (Blind 2012; Garrido et al. 2014; Deng and Zhang 2018)		0.93		0.94	0.84
We innovate to meet the standards or regulatory requirements	0.83		0.69		
We innovate to avoid infringement on legislation, regulations, and standards	0.98		0.97		
We innovate to not violate IP laws and regulations	0.92		0.85		

of knowledge and absorptive capacity (Escribano et al. 2009). The descriptive statistics show that 29.5 per cent of the firms in our sample do not have any R&D personnel, and less than half of them (48 per cent) have a full-staffed R&D department.

The second moderator, *industrial environment turbulence*, was measured with the existing scales adapted from Calantone et al. (2003) and Danneels and Sethi (2011), with four items for technology turbulence and four items for customer turbulence captured on a seven-point Likert-type scale. Following Droge et al. (2008), we treated *industrial environment turbulence* as a composite construct. An EFA with a principle component method produced one factor with an eigenvalue greater than 1, explaining 68 per cent of the total variance. All of the eight items were significantly loaded on the factor (ranging from 0.64 to 0.89) as shown in Table 3. The Cronbach's alpha value of 0.93 was largely above the threshold of 0.7, indicating high internal consistency.

3.2.4 Control variables

Larger companies possess more resources and may have less difficulty with regulatory compliance; younger firms, however, may have more flexibility to react to upcoming regulations (Blind 2016b). We thus controlled for *firm size* (a natural logarithm of the sales revenue) and *firm age* (the number of years since the firm was established). In the meantime, we accounted for two major inputs to a firm's internal R&D and innovation (Köhler et al. 2012; Teirlinck and Spithoven 2013): *R&D personnel intensity* was measured as the average percentage of full-time R&D personnel; and *human capital* was measured as the average percentage of employees having a university degree. Additionally, *export intensity*, measured as the percentage of exports in total sales, was controlled to account for innovation information gathered from foreign market linkages. Another dummy variable, *group affiliation*, was also included to capture whether the firm is part of a larger group from which it may also draw knowledge and information for innovation.

Finally, because innovation varies across sectors and industries (Malerba 2002), we controlled for this effect with industry dummies. The firm's four-digit sectoral classification codes (GB/T 4754-2011) were provided by STISC in the initial list. We matched these codes with the high-technology sector (manufacturing) classification (2013) issued by the National Bureau of Statistics of China, in order to determine the firms' affiliation to the high-technology sectors. The high-technology sector firms in the sample were further separated into two sectors: (1) *electronics and communication equipment* and (2) *computers, office equipment, and instruments*. Industry dummies were introduced with the *non-high-technology* sector as the benchmark in the estimation models.

The descriptive statics and pairwise correlations of all of the dependent, independent, and control variables are as shown in Table 4.

3.3 Methodology

The dependent variable (*product innovations*) in this study is a count outcome (non-negative integer). Poisson regression is often a reasonable technique for such data (Cameron and Trivedi 2013). However, the higher value of the SD over the mean of *production innovations* (see Table 4) highlights a possible violation of the equi-dispersion assumption of the Poisson model. In such a case, a negative binomial (NB) regression model, which has the same mean structure but introduces an extra parameter to model the overdispersion, was used (as suggested by Cameron and Trivedi 2013).

In order to test the moderation effect proposed in the hypotheses, a moderated multiple regression approach was adopted. Following Aguinis and Gottfredson (2010) and Dawson (2014), all of the independent and control variables (except the categorical ones) were mean-centred before the computation of the interaction terms to

Table 3. Measurement scale for industrial environment turbulence.

Construct	Factor loading and Cronbach's Alpha
Industrial environment turbulence (Calantone et al. 2003; Droge et al. 2008; Danneels and Sethi 2011)	α = 0.93
The technology is changing rapidly	0.84
Technological changes provide big opportunities	0.81
It is very difficult to forecast where the technologies will be in the next five years	0.64
A large number of new products/services have been made possible through technological breakthroughs	0.84
Our customers tend to look for new products/services all the time	0.86
Customers' preferences change relatively fast over time	0.89
New customers tend to have product/service-related needs that are different from those of existing customers	0.85
We are witnessing demand for our products and services from customers who never bought them before	0.82

Table 4. Descriptive statistics and correlations of the variables.

Variable	Mean	Std. dev.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11
Product innovations	18.40	53.01	0	410	1.00										
Firm size (sales revenue)	174.35 (28.17)	383.36	20 (3.23)	3681 (594.67)	−0.05	1.00									
Firm age	9.96	5.55	3	21	−0.04	0.26	1.00								
In-house formal R&D	0.48	0.50	0	1	0.17	0.00	0.03	1.00							
R&D personnel intensity	6.59	8.94	0	36	0.17	−0.06	−0.09	0.58	1.00						
Human capital	13.64	13.59	0	100	0.00	0.06	0.09	0.49	0.46	1.00					
Export intensity	59.39	39.71	0	100	0.01	0.16	0.13	0.00	−0.14	−0.04	1.00				
Group affiliation	0.33	0.47	0	1	−0.02	0.24	0.14	0.15	0.12	0.14	0.07	1.00			
Industrial environment turbulence	4.56	1.22	1	7	0.11	0.06	−0.08	0.33	0.25	0.29	−0.12	0.14	1.00		
Institutional incentives	3.64	1.69	1	7	0.15	0.17	0.03	0.43	0.37	0.33	−0.08	0.24	0.41	1.00	
Institutional pressures	4.15	1.80	1	7	0.12	0.14	0.06	0.22	0.09	0.14	−0.03	0.13	0.43	0.62	1.00

$N = 166$. All correlations with absolute value above 0.13 are significant at $P < 0.1$ level. Sales revenue is given in million RMB and million USD in brackets.

reduce potential multicollinearity. The variance inflation factors (VIFs) were tested for all of the coefficients after mean-centring and inclusion of all of the interaction terms. The results showed no evidence of multicollinearity with a maximum VIF value of 4.08, well below the ceiling of 10.

Nonetheless, there is still a potential threat of outliers due to the large SD that may bias the results. In this regard, we adopted a zero-inflated negative binomial (ZINB) model and also dropped the top 10 per cent of firms from the sample to test whether the hypotheses were robust under these conditions. The ZINB results were qualitatively identical to those of the NB model. Most of the hypotheses were well supported with only one exception: the positive moderating effect of *industrial turbulence* on the *institutional pressures–innovation* relationship in hypothesis 2b is not significant. The detailed robustness check results are not presented here due to space limitations; however, they are available to readers upon request. In the following section, we only report the NB results.

4. Results

Table 5 shows the NB regression results. Model 1 is the baseline model with all of the linear terms of the variables. The interaction terms were then entered hierarchically into Models 2–4. Model 4 is the full model with all of the interaction terms.

We first tested the main effects of the independent variables: *institutional incentives* and *institutional pressures*. In Model 1, the coefficient of *institutional incentives* is positive and significant ($\beta = 0.17$, $P < 0.1$), whereas the coefficient of *institutional pressures* is positive but not significant ($\beta = 0.07$, P < n/s). These results indicate that given the low internal capabilities of the Guangdong firms in our sample, the positive innovation-increasing effect of *institutional incentives* is stronger than its negative effect of resource tension, whilst there is no significant difference between the positive innovation-inducing effects and the negative innovation-blocking effects of *institutional pressures*. This finding is consistent across Models 2 through 4, where the interaction terms between the independent and moderating variables are included. It is not surprising to find that *institutional pressures* exhibit positive, negative, or insignificant main effects in different models, because the overall effect depends on the relative magnitude of the two competing positive and negative effects. In general, the (in)significance of the main effect of the independent variable or the moderator does not influence the existence of the moderation effect (Aguinis and Gottfredson 2010; Dawson 2014). Rather, the significance of the interaction term is the key and only determinant.

Hypotheses 1a and 1b propose that *in-house formal R&D* negatively moderates the effect of *institutional incentives* on *innovations*, but positively moderates the effect of *institutional pressures* on *innovations*. The results support both hypotheses: in Model 2, the interaction term *institutional incentives* × *in-house formal R&D* is negative and significant ($\beta = -0.43$, $P < 0.05$), whereas the interaction term *institutional pressures* × *in-house formal R&D* is positive and significant ($\beta = 0.47$, $P < 0.05$).

We further probed into these moderating effects with simple slope plots, as shown in Figure 2. Since *in-house formal R&D* is a

Table 5. Negative binomial regression results for Hypotheses 1–2.

Product innovations	(1)	(2)	(3)	(4)
Firm size (log of sales)	−0.2543	−0.1855	−0.3023	−0.2577
	(0.2075)	(0.1746)	(0.1841)	(0.1693)
Firm age	0.0146	−0.0033	0.0026	−0.0080
	(0.0340)	(0.0293)	(0.0304)	(0.0288)
In-house formal R&D	0.4801	0.3439	0.3748	0.1972
	(0.5385)	(0.5357)	(0.5261)	(0.5431)
R&D personnel intensity	0.0431**	0.0569***	0.0503**	0.0587***
	(0.0211)	(0.0204)	(0.0201)	(0.0203)
Human capital	−0.0236*	−0.0252**	−0.0282**	−0.0266**
	(0.0130)	(0.0120)	(0.0126)	(0.0117)
Export intensity	0.0042	0.0019	0.0041	0.0028
	(0.0048)	(0.0041)	(0.0042)	(0.0040)
Group affiliation	−0.1394	0.0024	−0.0145	0.0641
	(0.3555)	(0.3368)	(0.3371)	(0.3367)
Industrial environment turbulence	0.2494	0.1428	0.1900	0.1396
	(0.1979)	(0.1967)	(0.1700)	(0.1650)
Institutional incentives	0.1695*	0.4255**	0.2604**	0.3954**
	(0.0981)	(0.1799)	(0.1188)	(0.1877)
Institutional pressures	0.0703	−0.1635	0.0334	−0.1600
	(0.1173)	(0.1931)	(0.1273)	(0.1962)
Institutional incentives × In-house formal R&D		−0.4262**		−0.2408
		(0.2040)		(0.2111)
Institutional pressures × In-house formal R&D		0.4714**		0.4584**
		(0.2287)		(0.2162)
Institutional incentives × Industrial environment turbulence			−0.2846***	−0.2186**
			(0.1098)	(0.0994)
Institutional pressures × Industrial environment turbulence			0.2279*	0.0975
			(0.1273)	(0.0971)
_cons	2.6665***	2.6834***	2.5807***	2.6931***
	(0.5416)	(0.5202)	(0.4818)	(0.5216)
lnalpha	1.3325***	1.2916***	1.2947***	1.2714***
	(0.1679)	(0.1612)	(0.1609)	(0.1586)
pseudo R^2	0.0261	0.0312	0.0310	0.0339
Log likelihood	−521.9020	−519.1741	−519.2911	−517.7319
LR χ^2	47.8552	57.2731	52.1277	57.9136
N	166	166	166	166

Robust SEs in parentheses. Industry dummies included but not shown.
*P < 0.10, **P < 0.05, ***P < 0.01.

binary variable, the slopes are simply plotted at 0 and 1. In Figure 2a, *institutional incentives* have a positive and strong effect on *innovations* ($\beta = 0.43$, $P < 0.05$) when the firm does not perform *in-house formal R&D*. When the firm does perform *in-house formal R&D*, the effect is negative, but small and non-significant ($\beta = -0.0007$, n/s). This clearly indicates that conducting *in-house formal R&D* weakens the positive innovation-increasing effect and increases the negative resource tension caused by *institutional incentives*. Conversely, in Figure 2b, *institutional pressures* have a negative but non-significant ($\beta = -0.16$, n/s) effect on *innovations* when the firm does not perform *in-house formal R&D*, but the effect becomes positive and highly significant ($\beta = 0.31$, $P < 0.01$) when the firm does perform *in-house formal R&D*. This means that *in-house formal R&D* strengthens the positive innovation-inducing effect and mitigates the negative resource tension caused by *institutional pressures*. In sum, these results strongly support Hypotheses 1a and 1b. Moreover, in the full Model 4, where all of the four interactions terms of the two moderating variables are included, *institutional pressures × in-house formal R&D* is still positive and significant ($\beta = 0.46$, $P < 0.05$). *Institutional incentives × in-house formal R&D* turns out to be non-significant, however, indicating that the moderating effect of *in-house formal R&D* on the *institutional pressures–innovations* relationship is more robust.

The results also provide support to Hypotheses 2a and 2 b concerning *industrial turbulence's* negative moderating effect on the *institutional incentives–innovations* relationship and its positive moderating effect on the *institutional pressures–innovations* relationship. In Model 3, the interaction term *institutional incentives × industrial turbulence* is negative and highly significant ($\beta = -0.28$, $P < 0.01$), whereas *institutional pressures × industrial turbulence* is positive and significant ($\beta = 0.23$, $P < 0.1$).

We further probed into the confidence bands and regions of significance of the simple slopes, following Preacher et al. (2006). In Figure 3a, it is clear that the effect of *institutional incentives* on *innovations* declines significantly from positive to negative values while *industrial turbulence* increases. Moreover, the 90 per cent confidence bands do not include simple slopes of zero in regions where *industrial turbulence* is less than 4.89 or greater than 6.42. These are the two regions of significance ($P < 0.1$). In the first region (*industrial turbulence* <4.89), the net effect of *institutional incentives* on *innovations* is significantly positive, since their positive innovation-increasing effect is larger than the negative resource

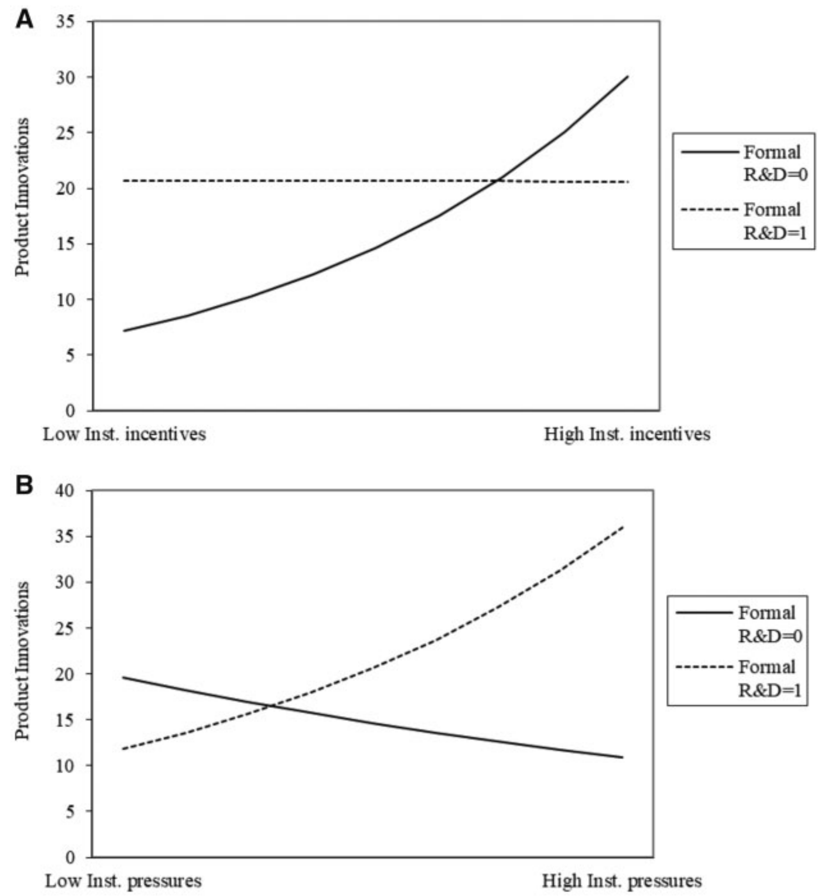

Figure 2. The moderating effects of in-house formal R&D (**a**) on institutional incentives–product innovation relationship and (**b**) on institutional pressures–product innovation relationship.

tension. In the second region (*industrial turbulence* >6.42), this net effect becomes significantly negative, because the growth in *industrial turbulence* weakens the positive innovation-increasing effect and increases the negative resource tension caused by *institutional incentives*. Considering the data range of *industrial turbulence* (1–7), this also indicates that *institutional incentives* will only have a significant negative effect on *innovations* at a high level of turbulence (above 6.42).

Similarly, Figure 3b shows that the effect of *institutional pressures* on *innovations* rises significantly from negative to positive values with the increase in *industrial turbulence*. The 90 per cent confidence bands do not include simple slopes of zero in regions where *industrial turbulence* is less than −5.32 or greater than 5.14. This means that *institutional pressures* have a significant negative effect on *innovations* when the level of turbulence is less than −5.32, which falls outside the data range of *industrial turbulence* (1–7). Thus, when the turbulence level changes from 1 to 5.14, the difference between the positive and negative effects of *institutional pressures* on *innovations* is still not significant. When *industrial turbulence* rises above 5.14, however, this net effect becomes significantly positive because the rise in *industrial turbulence* mitigates the negative resource tension and strengthens the positive innovation-inducing effect caused by *institutional pressures*.

In sum, Hypothesis 2a is strongly supported and Hypothesis 2b is well supported in Model 3. In the full Model 4, however, *institutional incentives* × *industrial turbulence* is negative and significant (β=−0.22, $P < 0.05$), and *institutional pressures* × *industrial turbulence* turns out to be non-significant; this indicates that the moderating effect of *industrial turbulence* on the *institutional incentives–innovations* relationship is more robust.

Finally, for the other control variables, the following is observed. *Firm size* and *age* are not significant in any model. *R&D personnel intensity* is consistently significant in all of the models, in line with the previous literature. *Human capital* is significant but negative in all of the models. A possible explanation could be that the *human capital* in these firms has already become economically inefficient in producing *innovations*. *Export intensity* and *group affiliation* are also not significant in any models.

5. Discussion and conclusions

This article explored the moderating effects of in-house formal R&D and industrial environment turbulence on the relationship between institutional drivers and firm innovation. Hypotheses were tested on a sample of manufacturing firms located in the central area of the PRD in Guangdong Province of China, where institutional changes and governmental policies play prominent roles in shaping innovation (Barbieri et al. 2012). The results offer important implications to both literature and practice, especially since this context is rarely studied and empirical evidence is largely absent.

This study contributes to the literature by disentangling the incentive and pressure effects of institutions on innovation. Previous

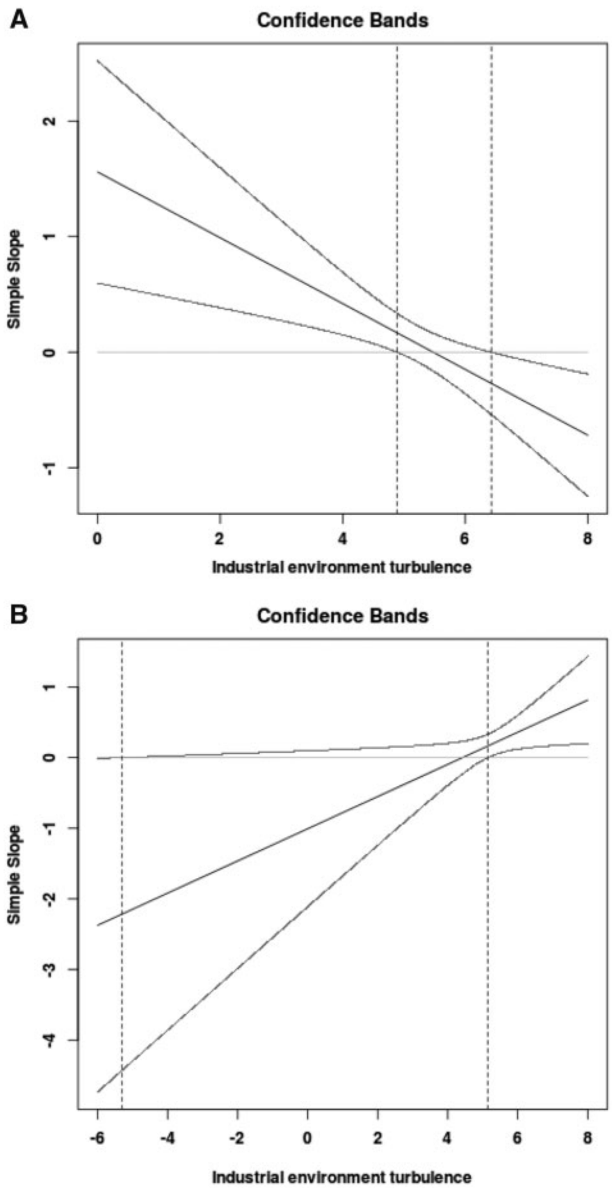

Figure 3. Ninety per cent confidence bands of the moderating effects for varying values of industrial environment turbulence: (**a**) institutional incentives–product innovations relationship and (b) institutional pressures–product innovations relationship.

studies on the institution-based view (Peng et al. 2009) or innovation systems (Edquist and Johnson 1997) have theoretically tapped into the divergent roles of institutions in term of incentives and pressures, however, most empirical studies have only focused on one specific type of institution without separating these two effects (Blind 2016b; Edler and Fagerberg 2017). This study thus extends the previous research by empirically testing the underlying incentive and pressure mechanisms across different types of institutions in the core areas of innovation regulation (Borrás and Edquist 2014).

Institutional incentives and pressures were found to have opposing positive and negative effects on firm innovation—the net effects are largely dependent on contingency factors. Specifically, in-house formal R&D and industrial turbulence negatively moderates the institutional incentives–innovations relationship but positively moderates the institutional pressures–innovations relationship. These findings resonate with recent studies concerning the interplay of institutions with firm heterogeneity, market uncertainty, technology maturity stages, and other contextual factors in affecting innovation (Zúñiga-Vicente et al. 2014; Costantini et al. 2015; Shen, Feng and Zhang 2016; Blind et al. 2017). The findings also help to resolve previous controversies, for example, whether environmental protection regulations have a negative or positive effect on innovation (Ambec et al. 2013) and the double-edged sword effect of government institutional support (Shu et al. 2015; Cunningham et al. 2016; Long and Wang 2019). The conditions of resource heterogeneity and industrial forces that are largely neglected in previous studies provide explanations that allow us to resolve those ambivalent results.

The findings also link the innovation systems literature (Edquist 2006) that focuses on institutions' impacts on innovation, with the institution-based view (Peng et al. 2009) that emphasises the joint forces of institutional transitions, industrial changes, and resource heterogeneity in shaping organisational strategy. It not only reveals the differential patterns of institutional incentives and pressures in affecting innovation, but also demonstrates their contrasting interplay with in-house formal R&D and industrial turbulence. This furthers the understanding on how the three legs of the strategic tripod (i.e. industry-based, resources-based, and institution-based views) (Peng et al. 2009) jointly influence firm innovation.

Besides theoretical contributions, this study also provides practical implications for firm management and government policy, not only for other specialised towns in Guangdong, but also for other regions in China, and other emerging economies in general. For firms operating in environments with pervasive institutional transitions, especially those in emerging economies, it is important to match resource and industrial conditions with institutional forces. Specifically, a firm with low internal capabilities and less established R&D processes could exploit institutional incentives to increase its innovation efforts and mitigate the resource tension caused by institutional pressures. Conversely, a firm with high internal capabilities and a formal R&D organisation could translate the institutional pressures into higher innovation investments to avoid the crowding-out effect of institutional incentives. Moreover, firms in stable and mature industries could make use of institutional incentives to explore new technological directions that would address or circumvent the innovation-stifling compliance requirements. Finally, firms in industries with turbulent technological and market changes could ensure that their innovation directions are legitimate and compliant with regulatory rules whilst balancing the tension between social innovations incentivised by institutional support and market innovations demanded by customers.

For policymakers, it is important to remember that the institutional incentives and the compliance pressures of regulations and innovation policies have divergent effects on innovation for firms with different resource and industrial characteristics. Our results show that institutional incentives are more helpful for firms in less turbulent industries or with lower internal capabilities, whereas compliance pressures work better for firms in more turbulent industries or with higher internal capabilities. Thus, when considering incentive-based or command-and-control designs (Stewart 2011) for innovation-related regulations and policies, special attention should be paid to the firm- and industry-specific characteristics in order to target the appropriate groups of firms.

This article has some limitations that constitute avenues for future research. First, the sample is limited to Chinese manufacturing firms located in the Guangdong Province. This limits the generalisability of the findings to other contexts. Nation- or region-specific institutions may lead to fundamentally different behaviours in firm innovation (Edquist 2006). Future empirical studies may consider other geographical contexts in different institutional settings. Secondly, this is confined to the roles of formal institutions in the core innovation regulation areas (Borrás and Edquist 2014) in driving technological and product innovations. Future studies may consider extending this framework to a wider range of formal and informal institutions, as well as to process and organisational innovations. Thirdly, the response variable (product innovations) in this study is a count outcome with a large SD over the mean. Although overdispersion is addressed by an NB model and we also tested the robustness of the results with a ZINB model, including an exclusion of the top 10 per cent of firms, the results should still be interpreted with caution due to the potential threat of outliers. Finally, the study remains cross-sectional in nature. Cross-sectional studies may raise concerns of endogeneity and the omission of unobserved heterogeneity. Although this study followed well-established methodological procedures to indicate explicitly the time reference period for each question (CIS 2014), as well as account for individual heterogeneity by a number of control variables, these concerns can only be more rigorously mitigated by using fixed or random effects estimations based on panel data in future studies.

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Conflict of interest statement

We have no conflicts of interest to disclose. We also assure that the article is the authors' original work, has not received prior publication, and is not under consideration for publication elsewhere.

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