Institutional Incentives and Pressures in Chinese Manufacturing Firms' Innovation, Published on Management Decision, June 2019, DOI: 10.1108/MD-08-2018-0933.

Institutional Incentives and Pressures in Chinese Manufacturing Firms' Innovation

Yongli TANG, Xinyue HU, Claudio PETTI and Matthias THURER

Abstract

Purpose – This paper investigates how Chinese firms' innovation is related to their perceived incentives and pressures from the transitioning institutional environment.

Design/methodology/approach – A sample of 166 manufacturing firms located in Guangdong Province (China), is analysed using binomial and moderated multiple regression models.

Findings – The results show that institutional incentives are more effective in promoting incremental innovations than radical ones, whereas institutional pressures are more pronounced in facilitating radical innovations than incremental ones. In addition, the interaction between the two divergent institutional forces is negatively related to innovation performance.

Practical implications – The findings inform managers and policy makers in institutional transition environments to consider and balance institutional forces. Firms should match the institutional incentives and pressures with their own innovation objectives in terms of incremental or radical goals, and take caution to deal with the divergent institutional directions, so as to avoid the negative interaction effects. Policy makers should take a systems approach when consider the incentive-based and/or command-and-control designs of innovation policies and regulations.

Originality/Value – The study contributes to existing literature on institutions and innovation by disentangling incentives and pressures of institutions, regulations and innovation policies, as well as the combined and interaction effects intrinsic within institutional mixes.

Keywords innovation; institutions; regulations; innovation policy; China

Paper type Research paper

Introduction

China has been undergoing fundamental and comprehensive institutional and economic changes since the opening-up in the late 1970s. As part of this transition, great government efforts have been devoted to transform China's innovation system. In recent years, China has introduced policy incentives to indigenous innovation (Peng et al. 2017), especially in prioritized areas. Meanwhile, China has also greatly strengthened its innovation-related regulations, including intellectual property rights (IPR) legislations, technical and product standards, and environmental regulations (Mangelsdorf, 2011; Zhao *et al.* 2016; Peng *et al.* 2017). In such a dynamic institutional environment, Chinese firms' innovation is shaped not only by the firm-specific resources, but also by the above institutional conditions and transitions (Peng *et al*., 2009; Cowden and Bendickson, 2018).

There has been significant research attention on the relationship between institutions and innovation. Yet, the majority focuses only on a single instrument or separated effects of specific institutions (Edler and Fagerberg, 2017), such as standards (Blind, 2016a), environmental regulations (Ramanathan *et al*. 2010; Chen *et al*. 2012), IPR legislations (Encaoua *et al.*, 2006), other types of economic and social regulations (Blind, 2016b; Sun *et al*. 2017), or various innovation policy measures (Edler *et al.*, 2016). Such approach neglects the interrelatedness and indivisibility of the institution mix in an innovation system that regulate firms' innovation in a combined and systemic way (Arnold 2004; Edler and Fagerberg, 2017). Moreover, most studies relate the strength or stringency of institutions to firm innovation (e.g. Blind, 2016b; Stewart, 2011), thus fail to separate the underlying incentive and pressure effects of institutions on firm strategic decisions and behaviors (Edquist and Johnson, 1997; Meyer & Peng 2016).

From the institution-based view (IBV), institutions impose incentive structures and pressures of legitimacy that shape the strategic choices of organizations (Meyer & Peng 2016). More specifically, in an innovation system (Freeman 1987; Lundvall 1992; Nelson 1993), the incentives and pressures exerted by institutions are analogous to "carrots" and "sticks" that play different roles in regulating innovation (Edquist and Johnson, 1997). These institutional forces affect the level of risk and uncertainty (Young et al. 2018) as well as the availability of resources (Mueller et al. 2013) in innovations. Combining the above theoretical insights from IBV and innovation systems, this study intends to investigate the relationship between innovation and the mix of institutions (Arnold 2004) within the core innovation regulation areas (Borras and Edquist, 2014) and innovation policies (Edler and Fagerberg, 2017) by exploring the separated forces and the interplay of institutional incentives and pressures. Moreover, as previous studies indicate that the impacts of institutions and regulations differentiate between incremental and radical innovations (Stewart, 2011; Blind 2016b), this study will further distinguish the differential associations of institutional incentives and pressures with these two qualitative distinct types of innovations.

To achieve these objectives, data was collected through a government supported survey on a sample of 166 manufacturing firms located centrally in the Pearl River Delta (PRD) of Guangdong Province (China), where institutional changes and policy supports play prominent roles in shaping firm innovation (Barbieri et al. 2010). The following section develops theory and hypotheses. The next two sections describe research methods and results. The last section provides discussion and concluding remarks.

Theory & hypotheses

Among the wide range of institutions in general, this study focuses on the formal institutions in the core innovation regulation areas (Borras and Edquist, 2014) closely related to technological innovation and products, including IPR legislations, technical and product standards, and environmental regulations. In addition, it also considers the supply-side and demand-side innovation policies that directly intervene in the generation and diffusion of innovations (Edler and Fagerberg, 2017).

Different types of institutions and regulations have different objectives in nature, and differ in their ways of affecting firms’ innovation. However, they all generate incentives as well as pressures of legitimacy to firm innovation (Edquist and Johnson, 1997; Meyer & Peng 2016). On the one hand, command-and-control instruments, such as directives of environmental protection, safety and health standards, and IPR enforcement laws, create pressures 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, IPR grants and certifications, provide incentives that steer the firm’s innovation towards desired policy, societal or environmental goals (Stewart 2011; Blind 2016b).

Moreover, from the internal perspective of the firm (Danneels and Sethi 2011), this study distinguishes between incremental innovation building upon the firm’s existing knowledge and capabilities, and radical innovation exploring new knowledge and capabilities (Benner & Tushman 2003). Previous studies indicated that institutional factors affect differently the level of risk and uncertainty in different types of innovation opportunities (Young et al. 2018), as well as the availability of resources in creation and diffusion of incremental and radical innovations (Mueller et al. 2013). Following these lines of arguments, this study will further distinguish the differential relationship of institutional incentives and pressures with incremental and radical innovations.

The Roles of Institutional Incentives

Institutional incentives in firm innovation come from the anticipated economic incentives or potential opportunities that reside in the institutional environment. They are essential in helping the firms to overcome market failures by providing motivations to invest in innovations inherently associated with uncertain returns (Edler and Fagerberg, 2017).

Institutional incentives increase the availability of resources in 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; whereas demand-side instruments motivate customers to commit resources to innovative products through public procurement and private demand support policies (e.g. tax incentives and subsidies), thus stimulate market demand and accelerate innovation diffusion (Edler et al. 2016). Ensured resource availability and secured funding support can also provide flexibility (Young et al. 2018) that allows the firm to deal with failures and iterations inherent in the uncertain innovation process.

Moreover, 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 regulations (Blind 2016b; Stewart, 2011) can motivate the firms to focus their limited resources on viable innovation opportunities. Demand-side measures (Edler et al. 2016) and technical standards (Blind, 2016a) can also reduce information asymmetries between innovators and users, and facilitate their decisions concerning innovation creation and adoption. Meanwhile, IPR legislations impose a legal exclusivity on the implementation of proprietary technology, thus 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 oriented towards social innovations (Stewart 2011) aiming at policy, societal or environmental goals. Such social innovations may contradict with the firm’s private investments in market innovations addressing customer needs. Thus, enjoying institutional incentives and government support for social innovations, the firm will become less willing to make private investments in divergent market innovations. Previous studies on public R&D support have found evidence of such crowding-out effect, whereby privately financed R&D decreases with the increase in government funding (Cummingham *et al*. 2016). Moreover, the halo-effect, which allows subsidized firms in the past to be more successful in the current program (Feldman and Kelley 2006), will further worsen the situation. A firm with continuous successes in receiving government funding for social innovations will have even lesser incentives to take the risks of private investment in confilicting market innovations.

More importantly, the crowding-out of private R&D investments associated with institutional incentives could be more severe in the case of radical innovations. Radical innovations are associated with a higher level of risk and uncertainty and are much more resource demanding than incremental innovations (Jansen et al. 2006; Mueller et al. 2013). Hence, facing the choices of market opportunities for radical and incremental innovations, a firm enjoying government funding in divergent social innovations will have lower tolerance to the higher risks of failures and larger investments in radical innovations.

In sum, institutional incentives are associated with increased R&D and innovation on the one hand and crowding-out of private investments in innovation on the other. Consequently, the net association depends on the difference of these two opposing effects. Moreover, because the crowding-out effect related to institutional incentives is more pronounced for radical innovations:

Hypothesis 1: A firm's perceived institutional incentives are more effective in promoting incremental innovations than radical ones.

The Roles of Institutional Pressures

Institutional pressures in firm innovation arise from the perceived pressures of legitimacy and compliance burdens under the imposed constraints and requirements in the institutional environment. The perceived pressures are associated with the regulatory stringency that represents the degree to which innovativeness and related burden is required for compliance (Stewart 2011). Previous studies indicated that high pressures from stringent institutions and regulations are related to two competing effects on firm innovation (Stewart 2011; Blind 2016b): (i) blocking innovation by diverting resources and limiting variations; (ii) spurring compliance innovations or circumventive innovations.

Intense efforts to address institutional constraints or compliance requirements will divert a firm's limited attention and resources away from more productive innovation activities (Stewart, 2011), hence reducing the availability of resource to innovation (Mueller et al. 2013). For example, the firm may be forced to increase its expenses to deal with the technical barriers such as performance benchmarks raised by standards or environmental regulations (Mangelsdorf, 2011; Stewart, 2011), or spend additional transaction costs to acquire external patent licenses or other proprietary technological knowledge to avoid infringement of IPR laws and regulations (Arora and Gambardella, 2010). Moreover, stringent rules and constraints can restrict flexibility of entrepreneurial decisions in innovation (Young et al. 2018). Constrained technological choices specified by standards, environmental regulations and IPR restrictions can hinder innovation by limiting the technical variations that could be otherwise combined to create innovations (Stewart, 2011). The innovation efforts of the firm may also be locked in the established technological trajectory of pre-existing standards and regulations (Blind, 2016a), thus facing exhausted technological opportunities and confined improvement space.

Institutional pressures are associated with the gap between the degree of innovativeness required for compliance and the firm's status quo of existing capabilities in technologies, products and processes (Stewart 2011). Incremental innovations build upon the exploitation of the firm's existing knowledge and capabilities, whereas radical innovations require the exploration of new knowledge and departure from existing skills (Benner & Tushman 2003). In this regard, a challenging gap pertaining to stringent regulatory requirements may be way beyond incremental improvements, and only can be addressed by departure from existing knowledge and capabilities, thus discourages or even nullifies the firm's incremental innovation efforts. It follows that the innovation-blocking effects of high institutional pressures are more negatively related to incremental innovations as compared with radical ones.

In contrast, the famous Porter Hypothesis posits that pressures from stringent regulations can trigger greater innovation and more fundamental solutions that have larger innovation offsets (Porter and van der Linde, 1995). A review of two decades of research into this hypothesis demonstrated that the empirical evidence largely supported the positive link between stringent environmental regulations and innovation (Ambec et al. 2013). It is claimed that although a present-biased firm manager has the behavioral inclination to go after "low-hanging fruits" and tends to postpone innovation investments, institutional pressures can force him to overcome this self-control problem by imposing stringent requirements of higher innovativeness (Ambec et al. 2013). When the distance between the stringent regulatory requirements and the existing products and processes exceeds incremental improvements, the firm will be forced either to quit the market or to retain legitimacy by exploring new knowledge and capabilities for compliance innovations or even circumventive innovations with more fundamental and radical changes (Stewart, 2011). In the face of stringent IPR legislations pertaining to high license fees and transaction costs, firms may also be pressured to penetrate through or circumvent the existing patent thickets in radically inventive ways (Shapiro, 2001). Thus, stringent regulations that exert great institutional pressures will block incremental innovations but at the same time induce more radical innovations.

The above discussion indicates that institutional pressures do not have a clear-cut one-direction relationship with firm innovation. The overall strength depends on the relative magnitude of the associated two competing innovation-inducing and innovation-blocking effects. Additionally, because the innovation-blocking effect is greater for incremental innovations, whereas the innovation-inducing effect is stronger for radical innovations:

Hypothesis 2: A firm's perceived institutional pressures are more effective in promoting radical innovations than incremental ones.

The Interaction Effect

Firms' perceived institutional incentives and pressures in their innovation are generated by a complex web of a myriad of institutional, regulatory and policy measures, instruments and devices, with often inconsistent goals, defined by different regulatory or policy-making entities (Edler and Fagerberg, 2017). Referring to the attention-based view of the firm (Ocasio, 1997), when managerial attention is forced to focus on institution pressures, there will be less attention allocated to institution incentives, and vice versa. Thus, these divergent institutional forces represent distinct directions that compete for the firm's attention and resources. For example, successes in pursuing institutional incentives, such as funding, subsidies or tax exemptions from domestic emission regulations and programs, will alleviate the firm's concerns with the compliance pressures pertaining to customer safety standards in the foreign markets, or even crowd-out firm private investments for compliance solutions in this regard. Conversely, struggling with pressing compliance pressures will distract the firm from potential institutional incentives and opportunities, and divert resources away. In addition, pressuring institutional constraints can reduced the flexibility of strategic choices (Young et al. 2018), thus may also thwart the firm's pursuit of relevant innovation opportunities manifested and supported by institutions.

In sum, the tension between institutional pressures and incentives may cause poor allocation of attention and resources, thus is associated with lower innovation performance:

Hypothesis 3: The interaction between a firm's perceived institutional incentives and pressures is negatively related to innovation performance.

Methodology

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 of China. The opening-up and institutional transition of Chinese economy since 1980s started in Guangdong, and specifically in the PRD, where the state and local governments experimented institutional, regulatory and policy measures of market-oriented reforms (Barbieri et al. 2012). Besides the overall turbulent changes in the national institutional framework, the policy efforts and supports of the local Guangdong provincial government also played crucial roles in shaping the local industrial development, most prominently the "Specialized Town Program" launched in 2000 (Bellandi & Di Tommaso 2005). Qingxi is a typical specialized town that started its industrial development from export-oriented labor-intensive products from 1980s and was encouraged by provincial government to promote photoelectric and communication products among other high technology products since late 1990s. The prominent roles of institutional changes and policy supports in shaping firm innovation at the specialized towns (Barbieri et al. 2010) 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 in 2014 was obtained from the local Science, Technology & Innovation

Service Centre (STISC). The questionnaires were sent by STISC via e-mail to all the firms in the list in December 2015. The required respondents should be the General Manager / CEO, or the CTO / Director of R&D department. STISC then helped collecting the completed questionnaires in paper form. By the end of January 2016, 166 valid responses were counted resulting in a response rate of 56.7%. The main characteristics of the firms in the sample are as shown in Table 1.

[Table 1 near here]

Variables and Measures

Dependent Variables

Firm's *innovation performance* is distinguished between *incremental product innovations* and *radical product innovations*. Product innovation was defined as the market introduction of a product that is new or significantly improved with respect to its characteristics or intended use, which excludes the simple resale of new goods purchased from other companies and changes of a solely aesthetic nature (CIS 2014). Product innovations must be new to the firm, but they do not need to be new to the market. Following the Survey of Business Strategies (SBSS) administrated by the Spanish Statistical Office (INE), radical product innovation was defined as a radical or truly innovative product representing a break or a drastic change from those previously developed by the company, that is, a new product that cannot be understood as a natural evolution of already existing in the company. This definition has been used in pervious empirical studies to distinguish novelty of innovations (e.g. Nieto & Santamaria 2007; Cruz-Gonzalez et al. 2015).

In this paper, radical product innovation is defined from the internal perspective of the firm in relation to its existing knowledge and capabilities (Benner & Tushman 2003; Jansen et al. 2006; Danneels and Sethi 2011). Since most of the Guangdong firms in our sample are still latecomers (Hobday 2005) in an emerging economy setting (Meyer & Peng 2016) and having little possibility to push the technology frontiers, such definition is suitable to capture the nature of their innovations that are radical relative only to its previous products, but still fall into the category of frugal innovations based on the ingenious use of existing technologies (Peng et al. 2018).

In the questionnaire, definitions of product innovation and radical product innovation were presented to the respondents. They were then asked to provide the cumulative numbers of *total product innovations* and *radical product innovations* introduced by the company in the past 3 years 2012-2014. In the end, the number of *incremental product innovations* is calculated by subtracting *radical product innovations* from *total product innovations.*

Independent Variables

In literature, well-developed scales of perceived *institutional incentives* and *pressures* in firm innovation are not available. The scales were therefore developed relying on previous studies on government support for innovation (Li and Atuahene-Gima, 2001; Shu *et al.*, 2016), and the measurement of different types of formal institutions (Garrido *et al*., 2014). Two three-item scales were developed for *institutional incentives* and *pressures* constructs respectively as shown in Table 2. These items were measured on a seven-point Likert-type scale. Although archival measures tend to be more objective, the reflective items developed in this study are advantageous because they can capture the varied perception of the institutional forces pivotal in innovation decisions by managers in different firms. Moreover, potential common method variance is less of an issue here, as the dependent variables are factual rather than perceptual. To further alleviate the concerns, EFA and CFA were conducted to test the validity and reliability of the new scales.

[Table 2 near here]

First, an exploratory factor analysis (EFA) was carried out to assess the underlying factor structures. It produced one factor with eigenvalue greater than 1, and another one very close to 1 (0.99), together explaining 87% of total variance. An orthogonal varimax rotation showed that all 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.

Next, a confirmatory factor analysis (CFA) using structural equation modelling (SEM) was carried out to assess the dimensionality, reliability and validity of the reflective measures. The overall model fit of the 2-factor model was χ^2=25.574, d.f.=8, p<0.0012, RMSEA=0.1150, CFI=0.98, TLI=0.96, SRMR=0.027. Thus, sufficient goodness-of-fit is supported according to the two-index combination rules suggested by Hu & Bentler (1999).

Furthermore, individual item reliability, composite reliability and average variance extracted (AVE) according to Fornell and Larcker (1981) were also calculated. As shown in Table 2, all 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 cutoff value of 0.7. The AVE values (0.77 for *institutional incentives* and 0.84 for *institutional pressures*) were also above the lower limit of 0.5. Thus, the model achieved satisfactory reliability.

Control Variables

First, the effects of *firm size* (natural logarithm of the number of full-time employees) and *firm age* (number of years since establishment) were accounted for. Meanwhile, the major inputs to firm R&D and innovation were also considered: *R&D personnel intensity* measured as the average percentage of full-time R&D employees; a dummy variable *formal R&D* indicating whether a firm has a dedicated R&D department; and *Human capital* represented by the percentage of employees having a university degree.

Firms search for innovation information from a variety of external sources including group linkages, market sources, universities and institutions (Köhler *et al.* 2012). The acquired information will inevitably affect the firm's perception of institutional incentives, opportunities and pressures in its innovation. These effects are taken into account by a number of control variables. A dummy variable indicating whether a firm has any *export* sales or not was controlled to reflect the firm's international 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 draw knowledge and information for innovation. Other information sources controlled include *market information* (from suppliers, customers and competitors), *university information* (from universities and public research institutes) and *institutional information* (from technical standards, and environmental, safety and health regulations).

In addition, *industrial environment turbulence* was controlled to reflect the rate and uncertainty of changes in technology and customer preference within the firm's industrial environment. It was measured with existing scales adapted from Daneels & Sethi (2011), with 4 items for technology turbulence and another 4 items for customer turbulence captured on a seven-point Likert-type scale.

Finally, innovation differences across sectors and industries were also controlled. The 4-digit sectoral classification codes (GB/T 4754-2011) of the firms provided by STISC were matched with the High-technology Sector (Manufacturing) Classification (2013) issued by National Bureau of Statistics of China (NBSC), in order to determine the firms' affiliation to high-technology sectors. The high-technology sector firms in the sample were further separated into 2 sectors: (i) *electronics and communication equipment*, (ii) *computers, office equipment and instruments*.

The descriptive statics and pairwise correlations of all the dependent, independent and control variables are as shown in Table 3. All the independent and control variables are measured as the average values in the period 2012-2014.

[Table 3 near here]

Estimation Specification and Procedure

The dependent variables (*incremental* and *radical product innovations*) in this study are count outcomes (non-negative integers). Moreover, the high values of standard deviations over the means (see Table 3) highlight the possibilities of over-dispersion. In such a case a negative binomial (NB) regression model was used as suggested by Cameron and Trivedi (2013). In order to test the interaction effect proposed in the Hypothesis 3, moderated multiple regression approach was adopted. Following Aguinis & Gottfredson (2010), all the independent and control variables (except the categorical ones) were mean-centered to reduce the potential multicollinearity. VIFs were tested for all the coefficients after mean-centering and the inclusion of the interaction term. The results showed no evidence of multicollinearity with a maximum VIF value of 2.55.

Results

NB regressions results are given in Table 4. The significance of the estimated value of *lnalpha* in each model confirms over-dispersion of the response variables and therefore the appropriateness of NB models.

[Tables 4 near here]

Hypothesis 1 posits that a firm's perceived *institutional incentives* are more effective in promoting *incremental innovations* than *radical innovations*. Evidence is found for this hypothesis: in Model 1 for *incremental innovations*, the coefficient of *institutional incentives* is positive and significant (β=0.25, $p<0.05$), indicating the associated positive innovation-increasing effect is stronger than the negative crowding-out effect; whereas in Model 3 for *radical innovations*, the coefficient is negative and significant (β=-0.23, $p<0.05$), demonstrating a larger associated negative crowding-out effect than the positive innovation-increasing effect. In order to find out whether the difference is statistically significant, a seemingly unrelated estimation technique (Weesie 1999) was adopted to combine the estimation results of separated models (Model 1 for *incremental innovations* and Model 3 for *radical innovations*) into one parameter vector and simultaneous (co)variance matrix for cross-model hypothesis testing. A highly significant Wald test statistic (chi2=16.91, $p<0.001$) based on the combined estimation results confirmed that *institutional incentives* have a higher overall association with *incremental innovations* than with *radical innovations*. Thus, Hypothesis 1 is strongly supported.

Hypothesis 2 proposes that *institutional pressures* are more effective in promoting *radical innovations* than *incremental innovations*. The results also support this hypothesis: in Model 1 for *incremental innovations*, the coefficient of *institutional pressures* is negative and not significant (β=-0.15, n/s); whereas in Model 3 for *radical innovations*, the coefficient is positive and highly significant (β=0.41, p<0.01). This means that for *radical innovations* the positive innovation-inducing effect associated with *institutional pressures* is significantly stronger than the negative innovation-constraining effect, thus the net positive coefficient; but for *incremental innovations* the associated two opposing effects do not have significant difference. A similar Wald test based on the combined estimation results of the two Models 1 and 3 also showed highly significant result (chi2=24.05, p<0.001) confirming the higher association of *institutional pressures* with *radical innovations* than *incremental innovations* as predicted in Hypothesis 2.

The findings also show strong supports to Hypothesis 3 concerning the negative interaction effect between *institutional incentives* and *pressures* on firm innovation. The interaction term of the two independent variables is negative and highly significant both in Model 2 for incremental innovations (β=-0.09, p<0.05) and in Model 4 for radical innovations (β=-0.15, p<0.01). However, the NB regression coefficients presented in Table 4 cannot tell us directly how the outcome is affected by the interaction, as the interaction effect is also dependent on the values of its components. In this regard, AMEs (average marginal effects) of *institutional incentives* and *pressures* are calculated and plotted graphically over varying values of the other variable following Williams (2012) to better probe into how their interaction amplifies or reduces *incremental* or *radical innovations*. As shown in Figure 1 (a) and (b), the AME of *institutional incentives* on *incremental innovations* decreases greatly as institutional pressures increases, and the AME of *institutional pressures* also drops significantly with the rise of *institutional incentives.* Similar patterns of the AMEs on *radical innovations* can be identified in Figure 1 (c) and (d). These clearly illustrate the significant negative interaction effects between *institutional incentives* and *pressures* and strongly support Hypothesis 3.

Finally, for the other control variables, *firm size* is significant in the models for *incremental innovations*, but not in any model for *radical innovations*. This is consistent with the "Schumpeter Mark II" model that larger firms produce more incremental innovations (Fagerberg, 2006). *R&D personnel intensity* is consistently significant in all models, and *formal R&D* is significant in models for *radical innovations,* in line with previous literature. *Human capital* is significantly negative in models for *incremental innovations*, but not in models for *radical innovations*. Since *R&D personnel intensity* already absorbs the effects of R&D related *human capital*, these results indicate that the non-R&D *human capital* has no significant effect on *radical innovations*, and is economically inefficient in facilitating *incremental innovations*. For the external information sources, *group affiliation* shows negative effect on *incremental innovations*, but no effect on *radical innovations*; *market information* is not significant for *incremental innovations*, but is positive in Model 3 for *radical innovations*; *university information* exhibits contrasting negative effect on *incremental innovations* and positive effect on *radical innovations*; and *institutional information* positively relates to *incremental innovations* but not to *radical innovations*. These results resonate with previous literature on innovative search (Köhler et al. 2012). *Industrial environment turbulence* is consistently significant in all the models for incremental and radical innovations, in line with previous literature (Danneels & Sethi 2011). Lastly, *firm age* and *export* are not significant in any models. Hence, for the firms in our sample, innovation performance does not vary systematically with *age*. Further, although *market information* is important for *radical innovations*, information gathered from *export* market linkages alone could not ensure innovation success.

Discussion and conclusions

This study investigates the relationship between institutions and innovation based on a unique dataset collected directly through a government supported survey in a Chinese specialized town. This bears important implications to both literature and practice, since this context is rarely studied and empirical evidence largely missing. It links institution-based view (Meyer & Peng 2016) and innovation systems literature (Edquist and Johnson, 1997) to disentangle the incentives and pressures of institutions and further differentiate their associations between incremental and radical innovations. The findings can help to resolve the ambivalent results of previous studies focusing only on the strength or stringency of institutions and regulations (Blind, 2016b; Stewart, 2011), and are also consistent with existing literature on government support for innovation (Li and Atuahene-Gima, 2001; Shu et al., 2016; Cummingham et al. 2016) in both developed and emerging economies. Thus, although the current study is conducted in a special context, it serves to further understanding of the institution-innovation relation in wider institutional settings.

Moreover, the study also extends previous studies by considering the system level effects of the mix of core innovation regulatory areas and innovation policies (Arnold 2004; Borras and Edquist, 2014). Previous literature has already theoretically tapped into the interrelatedness of the institutions, regulations and innovation policies, but most empirical studies only focused on one specific type of institutions or investigated the separated effects (Edler and Fagerberg, 2017). This study departs from the traditional impact evaluation of a single instrument (e.g. Czarnitzki, Hanel and Rosa, 2011), and establishes a more general relationship between different categories of government institutions and firms' capability to produce (radically) new products at the system level (Arnold 2004).

Besides theoretical contributions, this study also informs firm management and government policy. Firms operating in pervasive institutional transitions, especially those in the emerging economies, should match their innovation objectives with the institutional forces. Specifically, a firm can exploit institutional incentives to promote its incremental innovations, and translate institutional pressures into motivations towards radical innovations. For the policy makers, it is important to consider the different roles of institutional incentives and pressures in influencing incremental and radical innovations when considering the incentive-based or command-and-control designs of regulations (Stewart, 2011). A systems approach is called for to take into account the interplays of the combined mix of institutions, regulations and policies in an innovation system (Arnold 2004; Edler and Fagerberg, 2017).

This paper has some limitations that also constitute avenues for future research. First, the sample is limited to manufacturing firms located in Guangdong Province, limiting the generalizability of the findings to other contexts. Moreover, due to the absence of a proper control group of non-supported firms, the study also might suffer from potential sample selection bias whereby innovative firms are more likely to be selected for policy support. Future studies may consider using control groups and conducting comparative analysis in other countries and regions. Second, the current study focuses on formal institutions only. Formal and informal institutions are compensatory structures that combine to govern firm behavior (Peng et al. 2009). Therefore, integrating the effect of informal institutions in the current theoretical framework may lead to opportunities for new theories that have stronger explanatory power. Third, radical innovation here is defined from the firm's perspective and is new-to-firm in nature. Although this choice is based on innovation characteristics of the latecomer firms in an emerging economy setting in our sample, the findings should be interpreted with caution when generalized to new-to-market or new-to-world innovations. Future studies are called for to test the effects of institutional incentives and pressures on innovations of higher radicalness. Finally, the cross-sectional survey design may raise concerns of simultaneity. The study followed well-established survey procedures (CIS 2014) to indicate explicitly the time period referred to by each question, and accounted for individual heterogeneity by a number of control variables as suggested by the literature. Despite these measures taken, the findings should be interpreted only as correlations, not causal relationships. The potential concerns of simultaneity can only be more rigorously mitigated by a longitudinal panel design in future studies.

Acknolwedgements

This work has received funding from the National Natural Science Foundation of China (Grant Nos 71571088, 71401063); the Guangdong Provincial Department of Science and Technology (Grant Nos 2018A070712023, 2017A070706013); and the EU's Horizon 2020 Research and Innovation Programme under the Marie Sklodowska-Curie (G.A. No. 734447).

References

Aguinis, H. and Gottfredson, R. K. (2010), "Best-practice recommendations for estimating interaction effects using moderated multiple regression", *Journal of Organizational Behavior*, Vol. 31, pp. 776-786.

Ambec, S., Cohen, M. A., Elgie, S. and Lanoie, P. (2013), "The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness?", *Review of Environmental Economics and Policy,* Vol. 7 No. 1, pp. 2-22.

Arnold, E. (2004), "Evaluating research and innovation policy: a systems world needs systems evaluations", *Research Evaluation*, Vol.3, No.1, pp.3–17;

Arora, A. and Gambardella, A. (2010), "Ideas for rent: an overview of markets for technology", *Industrial and Corporate Change*, Vol. 19, No. 3, pp. 775-803.

Bagozzi, R.P., Yi, Y. and Phillips, L. (1991), "Assessing construct validity in organizational research", *Administrative Science Quarterly*, Vol.36, pp. 421–458.

Barbieri, E., Di Tommaso, M. R. and Bonnini, S. (2012), "Industrial development policies and performances in Southern China: Beyond the specialised industrial cluster program", *China Economic Review,* Vol. 23 No. 3, pp. 613-625.

Barbieri, E., Di Tommaso, M. R. and Huang, M. L. (2010), "Industrial Development Policy and Innovation in Southern China: Government Targets and Firms' Behaviour", *European Planning Studies,* Vol. 18 No. 1, pp. 83-105.

Bellandi, M. and Di Tommaso, M. R. (2005), "The case of specialized towns in Guangdong, China", *European Planning Studies,* Vol. 13 No. 5, pp. 707-729.

Benner, M. J. and M. L. Tushman (2003). "Exploitation, exploration, and process management: The productivity dilemma revisited." *Academy of Management Review*, Vol.28, No.2, pp.238-256.

Blind, K. (2016a), "The impact of standardisation and standards on innovation", in Edler, J., Cunningham, P., Gök, A., and Shapira, P. (Eds.), *Handbook of Innovation Policy Impact*, Edward Elgar Publishing, London, pp. 450–482.

Blind, K. (2016b), "The impact of regulation on innovation", in Edler, J.,Cunningham, P., Gök, A., Shapira, P. (Eds.), *Handbook of Innovation Policy Impact*, Edward Elgar Publishing, London, pp. 423–449.

Borrás, S. and Edquist, C. (2014), "Institutions and Regulations in Innovation Systems: Effects, Problems and Innovation Policy Design", Papers in Innovation Studies (no. 2014/29), Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University.

Cameron A.C.and Trivedi, P.K. (2013), Regression Analysis of Count Data (2nd edition), Cambridge University Press, Cambridge.

Chen, Y., Chang, C. and Wu, F. (2012), "Origins of green innovation: the differences between proactive and reactive green innovations", *Management Decision*, Vol. 50 No. 3, pp. 368-398.

CIS (2014), The Community Innovation Survey 2014: The Harmonised Survey Questionnaire, European Commission, Brussels.

Cowden, B. J. and Bendickson, J. S. (2018), "Impacts of regulatory focus and institutions on innovation", *Management Decision*, Vol. 56 No. 5, pp. 939-954.

Cruz-González, J., López-Sáez, P. and Navas-López, J. E. (2015), "Absorbing knowledge from supply-chain, industry and science: The distinct moderating role of formal liaison devices on new product development and novelty", *Industrial Marketing Management* Vol. 47, pp. 75-85.

Cummingham P., Gök, A., and Larédo P. (2016), "The impact of direct support to R&D and innovation in firms", in Edler, J., Cunningham, P., Gök, A. and Shapira, P. (Eds.), *Handbook of Innovation Policy Impact*, Edward Elgar Publishing, London, pp. 505–542.

Czarnitzki, D., P. Hanel and J. M. Rosa (2011). "Evaluating the impact of R&D tax credits on innovation: A microeconometric study on Canadian firms." *Research Policy*, Vol.40, No.2, pp.217-229.

Danneels, E. and Sethi, R. (2011), "New Product Exploration Under Environmental Turbulence", *Organization Science*, Vol. 22, No. 4, pp. 1026-1039.

Edler, J., Cunningham, P., Gök, A. and Shapira, P. (Eds.) (2016). *Handbook of innovation policy impact*, Edward Elgar Publishing, London.

Edler, J. and Fagerberg, J. (2017), "Innovation policy: what, why, and how", *Oxford Review of Economic Policy*, Vol. 33 No. 1, pp. 2-23.

Edquist, C. and Jonhson, B. (1997), "Institutions and organizations in systems of innovation", in Edquist, C. (Eds.), *Systems of innovation: Technologies, institutions and organizations*, Pinter, London, pp. 41-63.

Encaoua, D., Guellec, D. and Martínez, C. (2006), "Patent systems for encouraging innovation: Lessons from economic analysis", *Research Policy,* Vol. 35 No. 9, pp. 1423-1440.

Fagerberg J. (2006), "Innovation: A guide to the literature", in Fagerberg, J. and Mowery, D. C. (Eds.), *The Oxford Handbook of Innovation*,Oxford University Press, New York.

Feldman, M. P. and Kelley, M. R. (2006), "The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior", *Research Policy,* Vol. 35 No. 10, pp. 1509-1521.

Fornell, C. and Larcker, D. (1981), "Evaluating structural equation models with unobservable variables and measurement error" *Journal of Marketing Research*, Vol.18, pp. 39–50.

Freeman, C., 1987. Technology Policy and Economic Performance: Lessons from Japan. Pinter, London.

Garrido, E., J. Gomez, J. P. Maicas and R. Orcos (2014). "The institution-based view of strategy: How to measure it." BRQ-Business Research Quarterly 17(2): 82-101.

Hobday, M. (2005). Firm-level innovation models: Perspectives on research in developed and developing countries. *Technology Analysis & Strategic Management*, Vol.17, No.2, pp.121-146.

Hu, L. and P. Bentler (1999), "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives", *Structural Equation Modeling*, Vol.6, pp. 1–55.

Jansen, J. J. P., F. A. J. Van den Bosch and H. W. Volberda (2006). "Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators." *Management Science*, Vol.52, No.11, pp.1661-1674.

Köhler, C., Sofka, W. and Grimpe, C. (2012), "Selective search, sectoral patterns, and the impact on product innovation performance", *Research Policy*, Vol. 41 No. 8, pp. 1344-1356.

Li, H. and Atuahene-Gima, K. (2001), "Product Innovation Strategy and the Performance of New Technology Ventures in China", *Academy of Management Journal*, Vol. 44, No. 6, pp. 1123-1134.

Lundvall, B.A., 1992. National Systems of Innovation. Pinter, London.

Mangelsdorf, A. (2011), "The role of technical standards for trade between China and the European Union", *Technology Analysis & Strategic Management*, Vol. 23 No. 7, pp. 725-743.

Meyer, K. E. and Peng M. W. (2016). "Theoretical foundations of emerging economy business research." *Journal of International Business Studies*, Vol.47, No.1, pp.3-22.

Mueller, V., N. Rosenbusch and A. Bausch (2013). "Success Patterns of Exploratory and Exploitative Innovation: A Meta-Analysis of the Influence of Institutional Factors." *Journal of Management*, Vol.39, No.6, pp.1606-1636.

Nelson, R., 1993. National Innovation Systems: A Comparative Analysis. University Press, Oxford, New York.

Nieto, M. J. and L. Santamaría (2007). "The importance of diverse collaborative networks for the novelty of product innovation." *Technovation*, Vol.27, No.6-7, pp.367-377.

Ocasio, W. (1997), "Towards an attention-based view of the firm", *Strategic Management Journal*, Vol.18, pp. 187–206.

Peng, M. W., Ahlstrom, D., Carraher, S. M. & Shi, W. L. (2017). "History and the Debate Over Intellectual Property". *Management and Organization Review,* Vol. 13 No. 1, pp. 15-38.

Peng, M. W., S. Lebedev, C. O. Vlas, J. C. Wang and J. S. Shay (2018). "The growth of the firm in (and out of) emerging economies." *Asia Pacific Journal of Management,* Vol.35, No.4, pp.829-857.

Peng, M. W., Sun, S. L., Pinkham, B. and Chen, H. (2009), "The institution-based view as a third leg for a strategy tripod", *Academy of Management Perspectives*, Vol. 23 No. 4, pp. 63-81.

Porter, M. E., and van der Linde, C. (1995), "Toward a New Conception of the Environment-Competitiveness Relationship", *Journal of Economic Perspectives*, Vol. 9, No. 4, pp. 97-118.

Ramanathan, R., Black, A., Nath, P. and Muyldermans, L. (2010), "Impact of environmental regulations on innovation and performance in the UK industrial sector", *Management Decision*, Vol. 48 No. 10, pp. 1493-1513.

Shapiro, C. (2001), "Navigating the patent thicket: cross-licenses, patent pools, and standard setting", in Jaffe, A., Lerner, J. and S. Stern (Eds.), *Innovation Policy and the Economy*, Vol. 1, MIT Press for the National Bureau of Economic Research.

Shu, C. L., K. Z. Zhou, Y. Z. Xiao and Gao, S. X. (2016), "How Green Management Influences Product Innovation in China: The Role of Institutional Benefits", *Journal of Business Ethics*, Vol. 133, No.3, pp. 471-485.

Stewart, L. A. (2011), "The Impact of Regulation on Innovation in the United States: A Cross-Industry Literature Review", Information Technology & Innovation Foundation, Washington, DC.

Sun, F., Hong, J. J., Ma, X. Y. and Wang, C. Q. (2017), "Subnational institutions and open innovation: evidence from China", *Management Decision*, Vol. 55 No. 9, pp. 1942-1955.

Weesie, H.M. (1999), "On Seemingly Unrelated Estimation and the Cluster-Adjusted Sandwich Estimator", *Stata Technical Bulletin*, Vol. 52, pp. 34-47.

Williams R. (2012), Using the margins command to estimate and interpret adjusted and marginal effects, *The Stata Journal*, Vol.12, No.2, pp. 308-331.

Young, S. L., C. Welter and M. Conger (2018). "Stability vs. flexibility: The effect of regulatory institutions on opportunity type." *Journal of International Business Studies* Vol.49, No.4, pp.407-441.

Zhao, X. and Sun B. W. (2016). "The influence of Chinese environmental regulation on corporation innovation and competitiveness." *Journal of Cleaner Production*, Vol. 112, pp. 1528-1536.

Table 1. Main characteristics of the study sample

1. Number of employees	%
<50	1.2
51-300	51.2
301-500	21.1
501-2000	23.5
2000+	3.0
2. Sales Revenue (in million RMB)	
20-50	30.1
51-200	52.4
201-1000	14.5
1000+	3.0
3. Firm age (years)	
3-5	27.7
6-10	27.1
11-15	25.3
16 +	19.9
4. Industry affiliation	
Computers, communication & other electronics equipment	32.7
Electrical machinery & equipment	13.3
General and special purpose equipment	12.7
Metal products	9.6
Chemical products	9.0
Others Manufacturing	22.7
5. R&D personnel intensity	
0	29.5
0-10%	49.4
11-20%	13.9
21-30%	2.4
31%+	4.8

Table 2. Measurement scales for institutional incentives and pressures constructs

Constructs	Standardized Factor Loading	Cronbach's Alpha	Individual Item Reliability	Composite Reliability	Average Variance Extracted
Institutional incentives (Li & Atuahene-Gima, 2001; Shu et al. 2016; Wu 2017)		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; Nicoletti & Pryor 2006; Swann & Lambert 2010; Frenz & Lambert 2012; Wu 2017)		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		

Table 3. Descriptive statistics and correlations of the variables

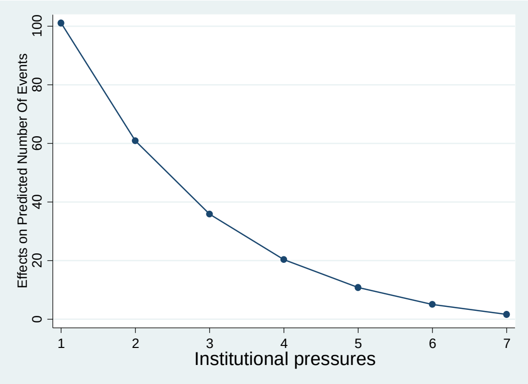
Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Incremental innovations	14.51	48.80	1.00														
2. Radical innovations	3.89	14.37	0.16	1.00													
3. Firm size (no. of employees)	520.80	791.26	0.01	-0.01	1.00												
4. Firm age	9.96	5.55	-0.04	0.02	0.14	1.00											
5. Formal R&D	0.48	0.50	0.12	0.24	0.01	0.03	1.00										
6. R&D personnel intensity	6.59	8.94	0.11	0.24	-0.03	-0.09	0.58	1.00									
7. Human capital	13.64	13.59	-0.05	0.18	0.09	0.09	0.49	0.46	1.00								
8. Export	0.83	0.38	-0.03	0.04	0.16	0.08	0.05	-0.05	0.16	1.00							
9. Group affiliation	0.33	0.47	-0.02	0.00	0.30	0.14	0.15	0.12	0.14	0.14	1.00						
10. Market information	3.55	1.52	0.07	0.17	0.08	-0.02	0.31	0.33	0.35	-0.01	0.13	1.00					
11. University information	2.04	1.33	0.03	0.28	0.04	-0.04	0.35	0.32	0.32	0.12	0.17	0.50	1.00				
12. Institutional information	2.89	1.62	0.20	0.19	0.11	0.04	0.34	0.22	0.29	0.03	0.22	0.64	0.62	1.00			
13. Ind. environment turbulence	4.56	1.22	0.06	0.22	0.05	-0.08	0.33	0.25	0.29	-0.01	0.14	0.42	0.24	0.31	1.00		
14. Institutional incentives	3.64	1.69	0.12	0.14	0.16	0.03	0.43	0.37	0.33	0.07	0.24	0.42	0.45	0.41	0.41	1.00	
15. Institutional pressures	4.15	1.80	0.07	0.19	0.10	0.06	0.22	0.09	0.14	0.02	0.13	0.38	0.20	0.36	0.43	0.62	1.00

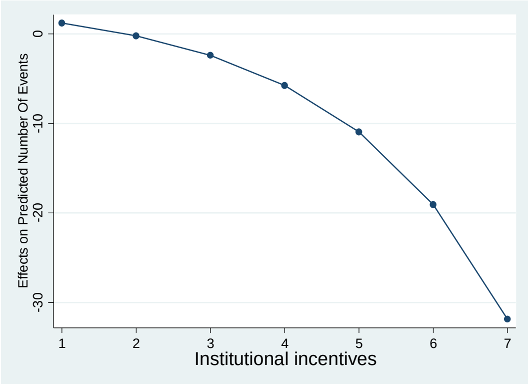
N=166. All correlations with absolute value above 0.13 are significant at $p<0.1$ level.

Table 4. Negative binomial regression results for hypotheses 1-3

	(1) Incremental innovations	(2) Incremental innovations	(3) Radical innovations	(4) Radical innovations
Firm size	0.5009**	0.5250***	0.0639	0.0011
	(0.2009)	(0.1946)	(0.1561)	(0.1567)
Firm age	-0.0373	-0.0336	0.0000	-0.0075
	(0.0244)	(0.0235)	(0.0234)	(0.0234)
Formal R&D	0.5472	0.3099	1.4353***	1.2593***
	(0.4032)	(0.3898)	(0.3554)	(0.3617)
R&D personnel intensity	0.0493**	0.0523**	0.0625***	0.0613***
	(0.0218)	(0.0212)	(0.0207)	(0.0216)
Human capital	-0.0382***	-0.0394***	-0.0043	-0.0060
	(0.0119)	(0.0113)	(0.0122)	(0.0124)
Export	-0.3805	-0.2178	-0.4657	-0.2669
	(0.3921)	(0.4007)	(0.3875)	(0.4350)
Group affiliation	-0.8322**	-0.9286***	0.2267	0.1660
	(0.3509)	(0.3412)	(0.3247)	(0.3408)
Market information	-0.0592	-0.1420	0.2413*	0.1824
	(0.1658)	(0.1686)	(0.1251)	(0.1305)
University information	-0.4393**	-0.4467***	0.5854***	0.4817***
	(0.1791)	(0.1705)	(0.1624)	(0.1612)
Institutional information	0.7201***	0.7280***	-0.1696	-0.0523
	(0.1834)	(0.1763)	(0.1525)	(0.1581)
Industrial environment turbulence	0.3414**	0.3890***	0.3325*	0.3995**
	(0.1356)	(0.1333)	(0.1727)	(0.1858)
Institutional incentives	0.2534**	0.3218***	-0.2283**	-0.0550
	(0.1047)	(0.1098)	(0.1068)	(0.1178)
Institutional pressures	-0.1501	-0.1556	0.4106***	0.3671***
	(0.1053)	(0.1039)	(0.1014)	(0.1156)
Institutional incentives ×Institutional pressures		-0.0883**		-0.1515***
		(0.0425)		(0.0573)
_cons	2.2967***	2.4704***	-0.2367	-0.2029
	(0.3938)	(0.4024)	(0.3980)	(0.4611)
lnalpha	1.2873***	1.2644***	0.6359***	0.5898***
	(0.1355)	(0.1348)	(0.1506)	(0.1605)
pseudo R^2	0.0565	0.0593	0.1718	0.1792
Log likelihood	-449.0419	-447.7225	-261.5506	-259.1981
LR chi2	78.0413	88.1539	114.8619	112.7718
N	166	166	166	166

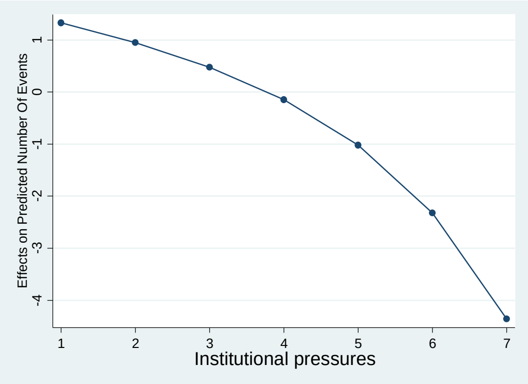
Robust standard errors in parentheses. Industry dummies included but not shown. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

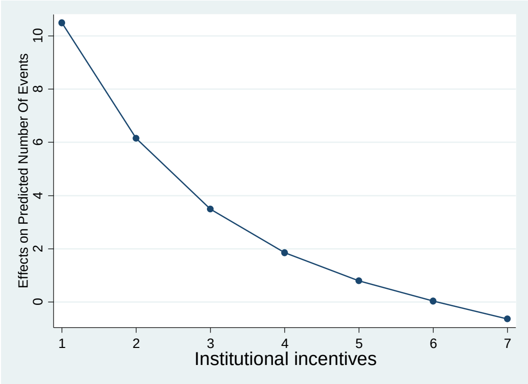




(a) Average marginal effects of Institutional incentives on Incremental innovations

(b) Average marginal effects of Institutional pressures on Incremental innovations





(c) Average marginal effects of Institutional incentives on Radical innovations

(d) Average marginal effects of Institutional pressures on Radical innovations

Figure 1 Average marginal effects of Institutional incentives and Institutional pressures in Model 2 and 4