# Exploring the Use of Patents in a Weak Institutional Environment: The Effects of Innovation Partnerships, Firm Ownership, and New Management Practices

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# Exploring the Use of Patents in a Weak Institutional Environment: The Effects of Innovation Partnerships, Firm Ownership, and New Management Practices


## Abstract

Most observations of the patent behavior of firms are derived from institutional environments in which relatively strong protection can be obtained, even if patents *per se* are imperfect protection mechanisms. As a result, the determinants of a firm's propensity to patent in a weak appropriability regime are still unclear. This paper advances our current understanding of patent behavior by exploring the effects of manufacturing firms' innovation partnerships, foreign ownership, and adoption of new management practices on the likelihood of patenting. Our analysis is based on the responses of firms to questions in the Brazilian Industrial Survey of Technological Innovation (Pintec). The findings presented here indicate that, despite the weaknesses of the patent system, firms engaged in innovation-oriented collaborations are more likely to patent than firms not involved in these partnerships. Additionally, the results reveal that domestic and foreign firms in a weak institutional environment are similar in their inclination to patent. Finally, the empirical exercise shows that when a patent system is characterized by high levels of formalism and low levels of safeguarding against infringements of property rights firms adopt novel management practices as substitutes for patents.



*Keywords:* patent; partnership; multinational enterprises (MNEs); management practice; institutions; Brazil

## 1. Introduction

The innovation literature suggests that an era of 'intellectual capitalism' has emerged (Granstrand, 1999, 2003) and that firms are pursuing patents more frequently (Lerner, 2002, 2009). Hence, the patent behavior of firms has received considerable attention in the academic literature (e.g., Galende, 2006; Novelli, 2015; Scotchmer, 2004; Somaya, 2012). However, most studies focus on firms operating in institutional environments in which relatively strong protections can be obtained (Forero-Pineda, 2006; Galende, 2006; James et al., 2013), even if patents *per se* are imperfect protection mechanisms. Thus, the recent surge in patenting may be particular to countries in which scientific and technological infrastructures are at the forefront. Firms operating in markets in which the judicial system does not favor patent enforcement may innovate without patenting due to the uncertain enforceability of their intellectual property rights (Bouet, 2015; Sarkissian, 2008; Waguespack et al., 2005). Innovation theory posits that patents are less useful in weak appropriability regimes (Teece, 1986). However, the determinants of a firm's propensity to patent in regimes with weak intellectual property rights (IPR) remains unclear (Candelin-Palmqvist et al., 2012; Hanel, 2006; Keupp et al., 2009; Song et al., 2013; Woo et al., 2015). The present study primarily seeks to fill this gap in our knowledge.

In this paper, we focus on three potential determinants of firms' propensities to patent: innovation-oriented partnerships, firm ownership (i.e., foreign *vs*. domestic), and the adoption of new management practices. We concentrate on these factors for several reasons. First, innovation-based collaborations have become widespread (Gesing et al., 2015; Hagedoorn, 2002; Hemmert et al., 2014; Laursen and Salter, 2006), but to the best of our knowledge, only a few studies have sought to directly address the effects of partnerships on firms' propensities to patent (Blind et al., 2006; Brouwer and Kleinknecht, 1999). The influence of partnership on

the propensity to patent is largely attributable to the increased likelihood of unintended knowledge spillovers. Patents are viewed as safeguards against partners' opportunistic behavior. However, in settings characterized by judiciary dysfunction, firms are likely to pursue alternative means of avoiding rent expropriation, such as informal, relational mechanisms of governance (Huang et al., 2013; Jean et al., 2014; Kotabe et al., 2014). As previous studies of the relationship between partnership and the propensity to patent have focused on countries with strong IPR systems, our knowledge of this relationship in business environments characterized by greater judicial uncertainty is limited.

Second, the literature on patenting has devoted little attention to the effects of ownership (i.e., foreign *vs*. domestic) on a firm's propensity to patent, especially in emerging economies (Keupp et al., 2012). Innovation theory suggests that in weak appropriability regimes, patents are less useful for firms hoping to reap the benefits of innovation (Teece, 1986). Thus, one would not expect foreign affiliates to be more inclined than domestic firms to patent. Nevertheless, the subsidiaries of multinational enterprises (MNEs) have, on average, a larger number of patents than the domestic firms of a focal country with a weak patent system (Albuquerque, 2000). Additionally, recent empirical evidence indicates that MNEs tend to replicate their home country patent behavior in host countries, even when the latter are emerging economies with fragile institutions (Athreye et al., 2014; Keupp et al., 2009). These findings appear to challenge innovation theory, warranting further investigation.

Finally, the literature on firms' propensities to patent largely builds on the neoclassical notion that firm size, market structure, and technological characteristics are central determinants of a firm's patent behavior (Griliches, 1990). Recent research, however, has suggested that other organizational aspects (e.g., managerial issues) also play a role (Webster, 2004). In fact, a firm's patent behavior also results from changes in management practices

(Ernst and Fischer, 2014; Hall and Ziedonis, 2001; Reitzig and Puranan, 2009). We argue that management practices are adopted not only to create value but also to capture a larger share of the value that a firm creates. This is especially relevant in our context, as, given the weakness of the IPR system, such practices may reinforce firms' abilities to capture value from innovation. Thus, enhanced management practices may complement patenting in firms' efforts to reap the benefits of innovation. Although there has been increasing interest in the extent to which complementarities exist between patents and other mechanisms firms employ to appropriate the returns from innovation (Somaya, 2012), as far as we know, no effort has been undertaken to determine whether the pursuit of enhanced management practices reinforces patenting. Thus, this question deserves further consideration.

Our analysis derives from the responses of firms to questions in the Brazilian Industrial Survey of Technological Innovation (Pintec) and is based on logit-model estimates of the probability that firms' various attributes make them more inclined to patent. We focus on Brazil because its patent system has been shown to be rather unpredictable and to operate within an inefficient legal system (Pereira and Plonski, 2009). The paper is organized as follows. In the next section, we briefly review the literature from which our hypotheses are derived. In the third section, we describe our dataset as well as the analytical framework employed in our analysis. Our estimation results are shown and discussed in the fourth section. Finally, conclusions are drawn in a final section.

## 2. Literature review and research hypotheses

Although the patent behavior of firms has received considerable attention in the academic literature (Novelli, 2015; van Zeebroeck et al., 2009), most studies have focused on developed economies with strong institutions and thus patent systems that are highly favorable to the enforcement of intellectual property rights. By contrast, there is little

evidence regarding how more fragile institutional settings affect firms' patent behavior. Why should we expect firms to behave differently in less vigorous patent systems? Dysfunctional administrative bodies pose challenges to patent prosecution and enforcement (Bouet, 2015; Drahos, 2008). Thus, firms operating in markets in which judicial systems do not facilitate patent enforcement are likely to adopt alternative approaches to appropriability (Hurmelinna-Laukkanen, 2009; James et al., 2013; Keupp et al., 2009). Weak appropriability regimes render patents less effective in appropriating the returns from innovation, and thus firms in such markets tend to more highly value other means (e.g., secrecy, control of complementary assets) of appropriating such returns (Teece, 2000). The adoption of other appropriability mechanisms does not imply that patents are not pursued (Zhao, 2006) but that a firm's propensity to patent (i.e. the likelihood of patenting) may be altered. In this paper, we explore the effects of partnerships, ownership, and adoption of new management practices on firms' patenting behavior.

*2.1 Partnerships and a firm's propensity to patent*

There is clear evidence that innovation partnerships have escalated since the 1980s, particularly in Europe, Asia, and North America (Gesing et al., 2015; Hagedoorn, 2002; Ma and Lee, 2008). Firms engage in collaboration to gain knowledge or specific resources needed to strengthen their competitive positions (Bekkers et al., 2002; Chesbrough, 2003; Giannopoulou et al., 2011; Hemmert et al., 2014). In fact, firms engaged in such innovation-based collaboration have seen increases in both economic performance (Belderbos et al., 2004b) and innovative output (Sherwood and Covin, 2008; Tether, 2002; Zengh et al., 2010). Although the latter depends, for example, on partner firms' depth of knowledge, the nature of the partnership, and the level of the vertical integration of the focal firm (Keupp and Gassmann, 2009; Li and Tang, 2010; Mention, 2011; Srivastava and Gnyawali, 2011), by

partnering, firms enhance their ability to innovate and are thus more likely to patent (Galende, 2006; Gesing et al., 2015; Schilling and Phelps, 2007).

While the exchange of knowledge increases the likelihood of innovation, it also encourages involuntary knowledge spillovers that can harm the continuity of the partnership (Hart and Moore, 1990; Veugelers and Cassiman, 1999). Thus, firms pursue safeguards against opportunistic behavior. One type of safeguard is a patent. Patents reduce transaction costs by documenting and formalizing a firm's knowledge. Indeed, as Brouwer and Kleinknecht (1999) observe, a firm becomes more inclined to patent and patents more frequently when it is involved in innovative collaborations. Blind et al. (2006) observe the same phenomenon, although at a lower level of statistical significance (i.e., 10%). Both papers provide evidence from institutional environments marked by stable and reliable governing rules and clear dispute settlement mechanisms. Emerging markets, however, tend to be characterized by market inefficiencies caused by weak regulatory institutions (Benoliel and Salama, 2010; Kotabe et al., 2014; La Porta et al., 1998; Miller et al., 2008). As a result, alternative mechanisms are expected to compensate for patent system ineffectiveness.

Innovation partnerships require not only strong commitment but also mutual reliability of the parties involved to protect the confidentiality of proprietary information exchanged (Hagedoorn, 2002; Robin et al., 2013). Social exchange theory posits that strong relational capital emerges from close interaction between partners (Kale et al., 2000). As parties continue transacting over time, social norms and trust tend to emerge, further supporting collaborative arrangements (Gulati, 1995; Huff and Kelley, 2003). In this way, relational norms promote greater support for the exchange of proprietary information, even in the absence of a legally binding mechanism, facilitating the transfer of information and expertise.

Relational mechanisms, however, are not substitutes for formal contracts but complement legal instruments (Poppo and Zenger, 2002). However, this complementary view pertains to strong institutional settings in which contracts can be enforced. In the absence of adequate legal enforcement, informal relational mechanisms of governance are expected to prevail (Hoskisson et al., 2000; Granovetter, 1985; Uzzi, 1997; Zaheer and Venkatraman, 1995). Thus, in environments characterized by weak institutions, firms are likely to resort to relational mechanisms (Huang et al., 2013; Kotabe et al., 2014; Zaheer and Zaheer, 2006). For example, using data obtained from a group of Argentine furniture manufacturers, Mesquita and Lazzarini (2008) have observed that relational governance promotes the provision of collective inputs, product innovation, and productivity gains. In other words, relational governance has helped firms supplant weak institutions and overcome infrastructural constraints. These findings suggest that patents in weak appropriability regimes are unlikely to play the same role that they play in more developed institutional settings. More specifically, relational governance may be more prevalent than patents either as a means of mitigating unintended knowledge spillovers or as a means of solving property rights disputes. As a result, all else equal, we do not expect firms engaged in innovation partnerships in weak institutional settings to be more inclined to patent than firms that do not engage in such collaborations, even if the former becomes more innovative. We hypothesize the following, holding all other factors constant:

> *Hypothesis 1: In a business environment characterized by a weak patent system, there is no difference in the likelihood of patenting between firms that engage and firms that do not engage in innovation partnerships.*

*2.2 Foreign ownership and a firm's propensity to patent*

The literature on innovation has long documented the commitment of multinational enterprises (MNEs) to patenting (e.g., Bertin and Wyatt, 1988; Taylor and Silberston, 1973).

Most notably, multiple authors have drawn attention to i) the relationship between host-country IPR systems and MNE entry mode (e.g., Glass and Saggi, 2002; Khoury and Peng, 2011; Pajunen, 2008; Seyoum, 1996) and ii) the relationship between host-country IPR systems and MNEs' local engagement in innovative activities (e.g., Athreye et al., 2014; Athukorala and Kohpaiboon, 2010; Branstetter et al., 2006; Ito and Wakasugi, 2007; Jean et al., 2014; Kumar, 2001; von Zedwitz and Grossman, 2002). Even if inconclusive, these studies collectively indicate that the nature of intellectual property rights legislation in host countries is relevant to MNEs' behavior in such markets (Cantwell and Piscitello, 2002; Lo, 2011; Woo et al., 2015). However, the extent to which foreign firms do or do not diverge from domestic firms in the propensities to patent in focal markets is not well established, especially in fragile institutional environments (Keupp et al., 2012).

To a large degree, extant evidence is consistent with innovation theory, which posits that a firm's inclination to patent does not depend on its ownership but rather on the degree of appropriability within which the firm operates (Ceccagnoli and Rothaermel, 2008; Teece, 1986). Given that affiliates of foreign firms and their domestic counterparts both operate in particular markets, their propensities to patent should not differ, as they encounter identical appropriability regimes. Along the same lines, one arm of institutional theory (derived from economics) argues that firms behave according to the set of fundamental political, social and legal ground rules—also known as institutions—that "establish (…) the basis for production, exchange and distribution" (Davis and North, 1971, p.6). Waguespack et al. (2009), for example, have shown that political instability in countries adversely affects the patent behavior of local firms. This arm of institutional theory conjectures that firms respond to the institutional environment regardless of their ownership. Another arm of institutional theory (derived from sociology) posits that firms operating within the same context should manifest similar behavioral patterns as a result of their pursuit of legitimacy; that is, they become

"isomorphic" (DiMaggio and Powell, 1983). According to both streams of institutional theory, as weak institutional settings do not encourage patenting, one should not expect subsidiaries of MNEs to be more inclined to patent than their indigenous counterparts. Together, innovation and institutional theories suggest that (everything else equal) both domestic and foreign firms should be comparably inclined to patent when they are established in the same institutional environment. Therefore, we hypothesize the following:

> *Hypothesis 2a*: *In a business environment characterized by a weak patent system, there is no difference in the likelihood of patenting between foreign and domestic firms*.

Nevertheless, parent and foreign affiliates of MNEs are likely to collectively hold more patents than domestic firms operating in single markets as a result of patent families – i.e. a set of patents issued in different countries to protect the same invention (Albuquerque, 2000). Moreover, existing evidence suggests that foreign affiliates' from relatively developed economies are more committed to innovation than firms from economies with poor innovation infrastructures (Costa and de Queiroz, 2002; Kannebley Jr et al., 2005). Zhao (2006) has found that, despite the weakness of certain patent systems, MNEs are very active in patenting in these countries. According to the author, this behavior derives from the integration of foreign subsidiaries into the global innovative activities of MNEs. To a large extent, these findings suggest that inter-firm differences in the propensity to patent do not result from ownership but from innovative effort. Thus, to assess the effects of ownership on the patent behavior of firms, one must control for inter-firm differences in innovative effort. Moreover, the literature has documented that differences in patent behavior between foreign and domestic firms can be attributed to the level of competition in the host country as well as to the absorptive capacity of firms in that market (de Faria and Sofka, 2010; Meyer and Sinani, 2009).

International business scholars argue that foreign and domestic firms may vary in value creation and value capture and thus respond differently to similar situations (Ghoshal and Barlett, 1990; Pérez-Nordtvedt et al., 2010). In addition, the international business literature recognizes that the actions of the subsidiaries of MNEs are subject to the demands of parent companies as well. Parent firms may thus require their foreign affiliates to adhere to their home country's institutional pattern. As Kostova and Roth (2002) have observed, foreign affiliates encounter an 'institutional duality' because they must cope with the pressures of both the home country and the host country's institutional domains. In fact, Keupp et al. (2009) and Yang et al. (2004) have determined that MNEs entering the Chinese market have made rigorous use of patenting, unlike Chinese firms. Additionally, this literature has documented that once MNEs are acquainted with the fragile local IPR regime, they start using other mechanisms to defend their 'property rights' (e.g., connections with government officials) but have not abandoned their inclination to use formal IPR. These findings suggest that foreign-owned affiliates in less developed institutional settings follow their home country's blueprint of using patents to ensure ownership of innovations. Therefore, foreign and domestic firms may manifest different patent behavior. As a result, based on this literature, we formulate the following hypothesis (*ceteris paribus*):

> *Hypothesis 2b*: *In a business environment characterized by a weak patent system, foreign firms are more likely to patent than domestic firms*.

*2.3 New management practices and a firm's propensity to patent*

The literature on innovation has documented that a pro-patent era has emerged (Blind et al., 2009; Corredoira and Banerjee, 2015; Granstrand, 2003). In such an environment, the strategic use of patents is widespread, and firms are keen to use new approaches to IPR to improve their performance (Andries and Faems, 2013; Rivette and Kline, 2000; Wada, 2005; Woo et al., 2015). For example, Kortum and Lerner (1999, p.21) have observed that "the

increase in patenting has been driven by changes in the management of innovation." Their hypothesis was corroborated by Hall and Ziedonis (2001), who detected that semiconductor firms have been more active in patenting as a result of, among other factors, changes in their managerial approach. Moreover, factors such as management style (Webster, 2004) and cross-functional involvement of individuals in the generation, protection, and utilization of IPR (Reitzig and Puranan, 2009) have been identified as determinants of firms' patent behavior. Collectively, these findings support the notion that the managerial approach explains part of the heterogeneity of the patent behavior of firms (Somaya, 2003; Reitzig et al., 2007). While it is intuitive that understanding the management of patent (or innovation)-related activities is important in assessing firms' patent behavior, the relevance of the adoption of a broader set of management methods to firms' inclinations to patent is less clear. Indeed, Mol and Birkinshaw (2009) argue that a broad outlook on the effects of the adoption of new management practices at the firm level is uncommon. But why focus on the adoption of new management practices as opposed to the management of patenting (or innovation) activities *per se*?

First, the adoption of new management practices reflects firms' intent with respect to improvements in their offerings as well as their work and knowledge flows (Birkinshaw et al., 2008; Cyert and March, 1963; Hollen et al., 2013; March, 2006). Thus, new management practices are intended to function as value creating devices (Hecker and Ganter, 2013; Leseure et al., 2004; Van Reenen, 2011). In fact, studies of the adoption of new management practices have shown positive relationships between management practices and both economic (e.g., Bloom and Van Reenen, 2007; Camisón and Villar-López, 2014; Mol and Birkinshaw, 2009) and innovation (e.g., Battisti and Iona, 2009; Hecker and Ganter, 2013; Laursen and Foss, 2003) performance. We argue, however, that new management practices work as value capture mechanisms as well. For example, as knowledge spillovers can result

from employees' freedom of communication (Liebeskind, 1997) and mobility (Delerue and Lejeune, 2010), firms can protect intellectual capital by deploying proper human resources management (Baughn et al., 1997; Mumford, 2000). In a similar vein, the adoption of supply chain management techniques is associated with improved firm performance because such techniques positively affect customer satisfaction (Ellinger et al., 2012), which in turn increases customer retention (Bolton et al., 2006), protecting a firm's stock returns from market movements (Tuli and Bharadwaj, 2009). Hence, initiatives that increase customer satisfaction allow firms to capture larger shares of the value they create. By expanding the scope of our study beyond the IPR/ innovation management level, we depart from prior studies, which have shed light on the effects of specific innovation-related management practices, and present a broader perspective on the overall effect of management on appropriability.

Second, there has been increasing interest in complementarities between patents and other mechanisms that firms use to appropriate the returns from innovation (James et al., 2013; Somaya, 2012). In particular, this stream of the literature has explored the interplay between patents and other formal (i.e., IPR) or informal (i.e., secrecy, lead-time) appropriability mechanisms (e.g., Amara et al., 2008; Gallié and Legros, 2012). To the extent that management innovation complements technological innovation (Hecker and Ganter, 2013), and the adoption of new management practices also leads to the capture of value, we argue that such practices complement patents. Finally, the literature offers very little empirical evidence regarding a relationship between a firm's adoption of new management practices and its patent behavior (Ernst and Fischer, 2014). Although recent studies on complementarities and appropriability have made some progress, as far as we can tell, there has been no effort to examine whether the pursuit of enhanced management practices works in tandem with patenting to reinforce firms' abilities to reap the benefits of innovation. This is

particularly relevant in our context, as the fragility of institutions promotes greater uncertainty (Kotabe et al., 2014), yielding managers more receptive to the adoption of these practices in an effort not only to ascribe legitimacy to their own actions (Daniel et al., 2012; Lieberman and Asaba, 2006) but to compensate for the weaknesses of the IPR system. Therefore, we hypothesize that, all else constant:

> *Hypothesis 3: In a business environment characterized by a weak patent system, the likelihood of patenting increases with the adoption of new management practices.*

One could argue that this hypothesis appears to contradict our second hypothesis because we both expect foreign firms to have better management practices and conjecture that domestic and foreign firms in weak institutional settings exhibit lower levels of patenting. MNEs can indeed benefit from intra-firm sharing of best practices both from headquarters to subsidiaries (Dinur et al., 2009) and from foreign to the home country operations (Edwards and Tempel, 2010). However, we do not take for granted the managerial superiority of MNEs' subsidiaries at the host-country level. As observed by Kotabe et al. (2002, p.92), "the impact of multinationality on firm performance depends on a number of firm-specific factors." Whereas MNEs can leverage resources across borders, their subsidiaries largely depend on resources similar to those that local firms require to operate. Moreover, even if foreign firms are more likely to adopt new management practices (Bloom and Van Reenen, 2010; Mol and Birkinshaw, 2009), leading to managerial skills superior to those of domestic firms, by testing our second and third hypotheses concurrently, we avoid confounding effects. More specifically, concurrent testing allows us to control for ownership as we assess the adoption of enhanced management practices.

## 3. Methodology

### *3.1 Data*

The dataset used to test our hypotheses was obtained from the Brazilian Industrial Survey of Technological Innovation (also known as the Pintec). The Pintec is a voluntary survey administered to firms with more than 10 employees in both the manufacturing and mining industries. For the purposes of this study, we focus only on the manufacturing industry, which is the context in which patents are typically employed (Levin et al., 1987). The Pintec was administered by the Brazilian Institute for Geography and Statistics (IBGE) with the purpose of collecting information on firms' innovative activities in Brazil. The survey instrument employed mirrors those used in the European Community Innovation Survey (CIS) and is used to collect qualitative and quantitative information regarding various firms' attributes related to innovation activities. In Brazil, the survey instrument was not completed by the respondents themselves and then returned to the surveyor. Instead, to ensure that various items in the questionnaire were fully understood, the IBGE's approach involved the recruitment and training of personnel who interviewed firms' representatives. For this purpose, either computer-assisted telephone interviews or personal interviews (*in loco*) were conducted. Moreover, in an effort to disclose more consistent information, IBGE cross-checks the Pintec's non-specific information with the dataset derived from PIA ("Yearly Industrial Research"). PIA covers a stratified sample of manufacturing establishments employing five workers or more and collects information on labor and production aspects of individual firms. The sample covered by PIA is all firms (i.e., census) with 30 or more workers plus a random sample of about 10% of the population whose firm sizes range from five to 29 workers.

The second round of the Pintec was administered in 2004 and relates to the innovative activities of firms in Brazil over the 2001-2003 period. This range of years was not a time

series but rather a period used as a reference for several questions. Therefore, in the current paper, we will examine a cross-section of firms. The final sample consisted of 10,624 firms, drawn from a population of 84,262 records of CEMPRE, an IBGE database of records of firms operating in Brazil. Our analysis, however, relies on a smaller number (approximately 1,700) because we only used valid responses. This restriction, however, does not seriously bias our analysis because IBGE generates weights for respondent firms according to their industries to correct for disproportionality of the sample.

Brazil is an interesting setting for this research because the efficiency of Brazilian courts is questionable (Yeung and Azevedo, 2011), as is that of the Brazilian Patent Office (also known as the INPI, which is the Portuguese acronym for the National Institute of Industrial Property). The INPI, for example, announced that its backlog has recently escalated and that granting a patent in Brazil takes on average eight years (INPI, 2011, p.21). Thus, difficulties in both enforcing contracts and obtaining patents pose challenges to those seeking patent protection in Brazil. Not surprisingly, Brazil has one of the weakest IPR systems of all countries (Zhao, 2006). According to Park's (2008) index for patent rights, the Brazilian system scored 3.59 (on a scale from 1 to 5) in 2005. In contrast, countries such as the US and UK scored 4.88 and 4.54, respectively. The Brazilian score also lags behind those of China (4.08), India (3.76), and Russia (3.68).

### *3.2 Variables*

#### *3.2.1 Response variable*

*Propensity to patent.* This information was extracted from a survey question that asked respondents whether they patented during the 2001-2003 period. Our *proxy* is a binary variable. Although this information limits our understanding of the number of patents applied

for or granted, the question allows us to distinguish those who hold patents from those who do not hold patents as part of their innovation strategy.

*3.2.2 Explanatory variables*

*Innovation partnerships.* A dummy variable was employed to capture the effects of innovation partnerships on a firm's propensity to patent. The questionnaire asked companies whether they cooperated with other organizations on innovation over the 2001-2003 period. This *proxy*, however, should be treated with caution due to potential endogeneity. In particular, one could argue that patents render firms less fearful of disclosing proprietary information and hence more likely to engage in partnerships. Moreover, to the extent that knowledge embodied in a patent grant is publicly disclosed, patents could be a source of cooperation partners (Hertzfeld et al., 2006). Models that fail to take endogeneity into account may result in biased results, even if they are non-linear models (Yatchew and Griliches, 1985). In our case, where both the response (i.e., 'the use of patents') and explanatory variables (i.e., 'innovation partnerships') are binary categorical variables, this problem could be overcome by the usual Heckman two-step procedure (Heckman, 1978). However, the nonlinearity of limited dependent variable models is a fundamental difficulty of the two-step correction procedure, and likelihood methods exhibit superior performance (Freedman and Sekhon, 2010). Therefore, one should jointly estimate the probit model of interest and a probit model for the endogenous variable that is the source of the problem. As consistent and asymptotically efficient parameter estimates are obtained through maximum likelihood estimation of the bivariate probit model (Holm and Arendt, 2013), we followed this empirical strategy in this paper.

*Ownership.* This attribute derives from a question on the Pintec regarding ownership of firms, where respondents are asked to choose one of three categories: domestic, foreign,

and domestic and foreign. This categorical variable was used in our models, with domestic ownership providing the basis of comparison.

*New management practices.* The Pintec also posed questions about whether firms had undergone organizational changes in 2001-2003. In one case, respondents were asked whether their firms had adopted 'enhanced managerial practices' during the 2001-2003 period, that is, whether a firm had implemented "new or significant changes in management methods". As this question may be too vague to elicit meaningful information, the interviewers were instructed to illustrate management practices, including reengineering, knowledge management, and total quality control management (and others), and clarify that the adoption of new management practices were intended to improve the quality of a firm's goods and services or the efficiency of its work or knowledge flows. While this approach does not fully eliminate measurement error, it ensures that respondents do not confound management changes with other organizational changes. Moreover, it retains management practices as a multidimensional construct (Whittington et al., 1999). Tether and Tajar (2008) and Evangelista and Vezzani (2010), for example, aggregate 'management practices' with other organizational changes as a *proxy* for 'organizational innovation'. Unfortunately, our dataset does not allow us to use a lagged variable, which would be more adequate because changes made to management practices are expected to have a lagged effect on patenting. In the absence of a better *proxy* for new management practices, we estimated consistency-check models in which we employed alternative organizational changes, namely, i) strategy realignment and ii) new organizational structure, rather than managerial changes. In this way, we expect to determine whether responses relating to the adoption of novel managerial practices were misinterpreted by respondents and associated with changes in other organizational attributes.

*3.2.3 Control variables*

*Insert Table 1 around here*

We adopted a set of control variables (Table 1) that the established literature suggests influence firms' inclinations to patent. *Firm size* captures both scale economies in the patent application process and firms' abilities to allocate more resources to patenting. *Innovative capacity* (*ex-ante*) represents a firm's stock of knowledge. *Innovative capacity* (*ex-post*) supplements any deficiency of the *ex-ante* innovative capacity variable and reflects a firm's degree of innovativeness. *Degree of competition* may impact the use of patents, as firms may be more concerned with rent expropriation under more competitive conditions. *Government support* relies on the assumption that patents may be less important for those firms that receive support from the government. In particular, firms in weak institutional environments tend to establish closer relationships with governments to compensate for market inefficiencies. *Industry* was controlled for because the patent behavior of firms also results from different technological opportunities and different appropriability regimes. As the latter result from the nature of technology and the strength of the patent system, and the focus of this paper is largely on the patent system dimension, controlling for industrial sector avoids confounding effects. Table 2 presents summary statistics and the correlation matrix for the main variables in our study. Industry-specific variables are not presented because they are too numerous to report here.

*Insert Table 2 around here*

*3.3 Method*

To determine how certain attributes impact the likelihood of patenting, we employed logit models to test our hypotheses. These models have a well-known structure and are appropriate when the dependent variable is discrete with only two categories (i.e., not

continuous), which is a feature of our response variable: whether or not a firm has used patents. In this case, the ordinary least squares method is biased and inefficient. Logit models estimate the probability of a positive outcome (i.e., that firms used patents), given a set of regressors. The estimation method used is the maximum likelihood method (Greene, 2012).

We observe the value ($y_i$) indicated by respondent *i* among the alternatives in the choice set, that is , $y_i = \begin{cases} 1 & if\ y_i^* > 0 \\ 0 & otherwise \end{cases}$ . Logit models assume that the dependent variable $y_i$ is generated by a latent variable $y_i$*, whose values are not observed but are a function of the vector **x** and of the vector **β** of unknown parameters. The latent variable can be considered random and is defined by the equation $y_i^* = \boldsymbol{x_i'\beta} + \varepsilon_i$, which includes a disturbance term that is assumed to be independent and identically distributed (i.i.d.), with a zero mean and a shared cumulative density function *F(ε)* that follows the standard cumulative logistic distribution $F(\varepsilon) = e^{\varepsilon}/(1 + e^{\varepsilon})$. In our estimation, however, we relax the assumption of an identical distribution and correct for heteroskedasticity using the Huber and White estimator of variance, so that the standard errors are robust to this deviation and can be used to make valid statistical inferences about the population parameters (Gourieroux, 2000). Thus, the model we seek to fit is:

$$\Pr(Patent = 1) = F(\beta_0 + \beta_1 Partner + \beta_2 Owner + \beta_3 NewMngt + \beta_n controls).$$

However, we have also argued that firms may simultaneously choose to use patents and adopt new management practices, as the latter complement the former. We therefore have a system of two equations – one for the choice of patents and one for the choice of new management practices. As there may be omitted variables in these choice processes, estimation of independent logit/probit models produces inefficient estimates. We have thus used a bivariate probit model in which the (latent) dependent variable $y_{i,c}^*$ of each equation

represents the type of component 'c' (patents; new management practices) that each firm *i* adopts. The set of explanatory variables does not vary across equations (i.e., equations are seemingly unrelated), and their joint estimation controls for the existence of mutual correlations ($\rho$) between the disturbances (Greene, 2012).

## 4. Results and discussion

### *4.1 Empirical Findings*

Our initial analysis indicates that trademarks and secrecy are the most popular instruments in Brazilian manufacturing, followed by industrial design and patents, respectively (Table 3). However, patents are used more often than industrial design among firms that innovate at either the product or process level, with innovations that are novel to the national market. Table 3 also indicates that lead time becomes more important when firms innovate.

*Insert Table 3 around here*

Our preliminary analysis of firms' responses also indicates that MNEs report using patents more often than domestic firms. Among foreign-controlled firms, 20.6% report having used patents, whereas among domestic firms, the proportion of patent users is 5.6%. Firms that report engaging in innovation collaboration also appear to exhibit greater patent use than firms that do not participate in such partnerships: 24.0% and 5.3%, respectively. This apparent increase in patenting appears to result from close collaboration with suppliers, clients/customers, and universities, which are the most frequent partners (41%, 36%, and 34% of collaborative partners, respectively). Our sample firms establish very few collaborative partnerships with competitors (accounting for as little as 6% of firms that cooperate). In addition, the positive correlation between ownership and partnership in Table 2 indicates that

MNEs appear to pursue innovation cooperation more frequently than domestic firms. The share of patent users also differs among firms that have adopted new management practices and those that have not adopted such practices: 9.9% and 5.3%, respectively. Moreover, the percentage of patent users varies by industrial sector (Table 4). In particular, firms that manufacture precision instruments (e.g., medical devices, optical instruments, devices used in industrial automation) account for the largest share of patent users. This, however, does not mean that innovation cooperation is more easily observed in this sector. In fact, partnerships for innovation in our sample firms are established more often in the 'office and computing equipments' sector, where 18.2% of firms established this type of cooperation. In contrast, this figure is as low as 4.8% in the precision instruments sector.

*Insert Table 4 around here*

Table 5 presents estimates of the econometric models employed to test our first and second hypotheses (assuming that a more suitable econometric framework is needed to test the third hypothesis). These estimates derive from models with different control variables for innovative capacity (*ex-ante* and *ex-post*, respectively). Our results are consistent across the econometric models (also see Appendix 1). Variability of the *proxies* for innovative capacity does not strongly affect the estimates. Additionally, the best fit (i.e., lower AIC and BIC) was obtained from the first structural econometric model (M1). The results also reinforce the preliminary finding (i.e., Table 3) that process innovators are less inclined to pursue patents. Moreover, market power, *proxied* by firm size, does not appear to fully compensate for imitation, as larger firms are often more inclined than smaller firms are to patent. In turn, government support does not show any effect on firms' inclination to patent. Interestingly, competition matters only when firms depend on foreign trade, whereas firms competing at the national level are not more inclined to patent than firms competing at the local level. The

estimates are also consistent with theoretical arguments that firms' inclinations to patent vary by industrial sector. Nevertheless, after controlling for other characteristics, firms in the 'precision instruments' sector (our base of comparison) are not always the most patent-oriented firms. Our estimates indicate that firms are less likely to use patents, compared with firms in the precision instruments industry, when they are in the food, beverages and tobacco industry, the textiles and clothing industry, the paper and cellulose industry, the basic metals industry, the communication equipment industry, or the motor vehicles industry (due to space restrictions, results for industry dummies are not reported here but are available upon request).

*Insert Table 5 around here*

In a preliminary analysis of the dataset, foreign-owned Brazilian manufacturing firms appeared to patent more often than domestic firms. Although this finding is inconsistent with hypothesis 2a, it does not account for other confounding effects that we attempted to control for in our regression analysis. In controlling for such effects, we found that ownership has no effect on how inclined a firm is to patent. As seen in Table 5, *ceteris paribus*, foreign firms do not significantly differ from domestic firms in their propensity to patent. The effects of innovation partnership are also contrary to expectations. The positive, statistically significant effect of this factor is consistent with the findings of prior studies and thus runs counter to our relational argument. Despite the weakness of the institutional setting of our empirical exercise compared with that of more developed countries, our first hypothesis is rejected because firms engaged in innovation-oriented collaboration are more inclined to patent than firms not involved in such partnerships.

To assess the effect of the adoption of novel management practices, we extended model M1, as this model exhibited best fit among the models in Table 5. A somewhat

counterintuitive result emerged: adoption of new management practices is negatively related to the use of patents (model M5 in Table 6). We tested different organizational changes (i.e., strategy re-alignment and new organizational structure, respectively) as consistency checks. Models M6 and M7 clearly produce results that differ from those of model M5; thus, the result for the adoption of new management practices is not an artifact of misinterpretation by respondents. The extended models also suggest the same interpretations of the effects of other independent and control variables on the propensity to patent, corroborating the consistency of the econometric estimates. Moreover, the effects of innovation partnership and ownership are largely unchanged. The weak statistical significance of the impact of foreign ownership (model M5) reinforces our suspicion that foreign firms may be more skillful than domestic firms in adopting sophisticated management practices. Table 6 also presents marginal effects (M5 dy/dx), which shed light on the extension of these effects. While it is clear that both innovation partnerships and the adoption of new management practices affect firms' inclinations to use patents, the magnitudes of these effects in absolute terms are not large. Specifically, they give rise to a 5% increase (for partnerships) or decrease (for new management practices) in the likelihood of using patents.

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*Insert Table 6 around here*

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To the extent that new management practices could enhance firms' abilities to capture value from innovation, they could complement firms' patenting behavior. While our findings indicate the contrary, these results could arise from our estimation framework. Thus, we test the relationship between the use of patents and the adoption of new management practices, assuming simultaneity in these decision processes. In this circumstance, we jointly model the decision to use patents and the decision to adopt new management practices, using a bivariate probit model. Note, however, that the probit parameter estimates (Table 7) differ from those

of logit models (Tables 5 and 6) because the transformation from the coefficient to a probability in probit models is different from the equivalent transformation in logit models. Coefficients in probit models are between 50% and 60% smaller than the corresponding logit coefficients (Liao, 1994). Table 7 reveals a (statistically significant) negative correlation between the error terms of the two models (i.e., $\rho$= -0.17**); that is, these alternatives are substitutes. This finding is consistent with our prior estimation and rejects hypothesis 3 (that the likelihood of patenting increases with the adoption of new management practices).

*Insert Table 7 around here*

*4.2 Robustness checks*

In addition to the consistency checks and the supplementary econometric framework described above, we estimated models with different proxies for firms' (*ex-ante*) innovative capacities (Appendix 2 – models A2.1-A2.3) and an augmented model incorporating potential omitted variables (Appendix 2 – model A2.4). Models A2.1 and A2.2 employ slightly different proxies for (*ex-ante*) innovative capacity (see note 'c' in Appendix 2), but both models yield results similar to those of our reference model (M1 in Table 5). As expected, there was a considerable sample enlargement when the 'percentage of personnel holding a science or engineering degree' was used to represent innovative capacity and no restrictions to R&D respondents were applied (model A2.3). Even so, the results did not suggest dissimilar conclusions. Therefore, non-reporting of R&D is not problematic, at least among the firms sampled. In addition, incorporation of the effects of group membership (Sea-Jin et al., 2006) and age (Balasubramanian and Lee, 2008) neither led to (statistically) significant estimates nor affected previous estimates (model A2.4). Thus, our reference model does not appear to suffer from omitted variables bias.

Another consideration meriting further attention in estimating firms' propensities to patent was potential endogeneity. We expect that firms accustomed to patent protection are less fearful of sharing knowledge and therefore more likely to engage in partnerships (Fritsch and Lukas, 2001; Hertzfeld et al., 2006). To overcome this problem, we followed Freedman and Sekhon (2010) and jointly estimated the probit model of interest and a probit model for the endogenous variable, using maximum likelihood estimation. This resembles the econometric framework employed above to test complementarities between the use of patents and the adoption of new management practices. In this case, however, estimation of the (potentially) endogenous variable should account for an instrumental variable. The instrument employed to test for endogeneity was the importance of external sources of information (coded "1" when respondents ranked any external source of information as highly important and zero otherwise) because innovation cooperation "is more likely if incoming spillovers coming from the potential partners are more important" (Belderbos et al., 2004a, p.1245).

The estimation results do not support the endogeneity hypothesis, as $\rho$ is not different from zero, and the estimate for innovation partnerships in the probit model of interest is not statistically significant (Appendix 3). We also employed this framework to test for endogeneity in models M2 (Table 3) and A2.3 (Appendix 2), as there could be an R&D reporting bias. The results, however, were consistent (i.e., no endogeneity). As an alternative, we employed commonly used frameworks to address endogeneity when either the potential endogenous variable is continuous (Rivers and Vuong, 1988) or the potential endogenous variable is binary but the response variable is continuous (also known as the treatment effects model – see Greene, 2012). Neither approach was indicative of endogeneity.

*4.3 Analysis and discussion*

Our motivation to probe firms' propensities to patent in a weak patent system arises from both theoretical and empirical research streams. Theory suggests that institutions are pivotal in shaping firms' behavior (North, 1991; Pearce et al., 2009; Peng et al., 2008), and empirical evidence has supported this proposition (Kotabe et al., 2014; Khoury and Peng, 2011; Weguespack et al., 2005). Notwithstanding the characteristics of the institutional environment, the findings reveal an intriguing pattern (Tables 5 and 6): that a firm's propensity to patent is governed by factors already observed in more developed institutional settings, with firm size, innovative capacity, and technological opportunities being the most prominent determinants. Moreover, government support does not render firms more active in patenting, which is consistent with the notion that publicly funded innovative activities should not be fully privately appropriated (Griliches, 1990) and that there may be other more effective means of capturing value in settings characterized by weak institutions (Hoskisson et al., 2000). Actually, the weakness of the patent system where our sample firms operate appears to affect their behavior with respect to how they attempt to capture the returns from innovative effort.

The literature on firms' propensities to patent (Blind et al., 2006; Brouwer and Kleinknecht, 1999) has argued that patents are safeguards against opportunistic behavior in situations of knowledge disclosure. Indeed, how to handle proprietary information is a fundamental issue when agents engage in joint innovation efforts (Colombo et al., 2006; Hertzfeld et al., 2006). By codifying knowledge, patents reduce transaction costs and have the added benefit of signaling to third parties that retaliation is an option in cases of rent expropriation (Gambardella et al., 2007). Nevertheless, due to the weakness of legally binding mechanisms in fragile judicial systems, we expected relational norms (as opposed to contracts) to foster greater support for the exchange of proprietary information (Mesquita and

Lazzarini, 2008). The results, however, led us to reject our first hypothesis, which posited that in our empirical setting, there would be no differences in the propensity to patent between firms that engage and firms that do not engage in innovation partnerships. Although this finding contradicts our expectation, it is not really surprising. Our result reinforces the standard explanation for this phenomenon; that is, firms that partner in innovative endeavors are more likely to seize new opportunities (Frenz and Ietto-Gillies, 2009; Nieto and Santamaría, 2007) and are thus more likely to encounter prospects to patent. Actually, informal talks with several R&D executives revealed that this was why they used patents more often when partnering with other organizations. Indeed, Table 2 indicates that our sample firms that established innovative partnerships are those with relatively low levels of internal R&D expenses (i.e., are less R&D intensive). Thus, firms tap into external knowledge as a means of supplementing their internal R&D efforts.

Another possible explanation is that firms follow option-based reasoning. They purchase a relatively inexpensive option (i.e., a granted patent) that allows them to assess whether enforcement is a feasible alternative by the time that their IPR is infringed (Geroski, 1995). Thus, despite the institutional weakness of our empirical setting, firms may address patent issues with a long-term outlook that eventually frees them from dependence on relational mechanisms when engaging in collaborative arrangements. Moreover, the literature on strategic management has shown that formal (e.g., contractual) and informal (i.e., relational) mechanisms can complement each other in interorganizational relationships (Poppo and Zenger, 2002). Thus, a greater propensity to patent among firms involved in innovation partnerships does not indicate that relational mechanisms are unimportant. The absence of endogeneity in our model (Appendix 3) is consistent with this observation because the weakness of the patent system is likely to make firms (even more) skeptical of the effectiveness of patents. Thus, merely holding patents may not make firms feel more secure in

approaching new partners; rather, they may believe that relational norms are more effective than patents in preventing knowledge spillovers. At best, our findings reinforce Duan's (2012) case-based evidence for the Chinese market, where firms use contracts to benchmark their actions (and those of their partners) against *ex-ante* expected obligations. Thus, even if formal rules are difficult to enforce in dysfunctional judicial systems, and relational governance prevails, firms pursue available contractual arrangements.

Regarding ownership structure, our raw analysis (i.e., not controlling for firms' other attributes) is consistent with earlier findings that domestic firms are less inclined to patent (and thus, the analysis supports hypothesis 2b). However, our more rigorous analysis supports hypothesis 2a: that foreign firms are no different from domestic firms in their propensities to patent. Therefore, despite MNEs' specific advantages over single-market firms in their capacities to leverage assets and capabilities (Ghoshal and Barlett, 1990), their propensities to patent in the focal market appear to conform to the business environment in that their inclinations to patent are no different from those of indigenous firms. Thus, unobservable attributes particular to MNEs are evidently not strong enough to induce distinct patent behavioral propensities. Additionally, even if domestic and foreign firms differ in their knowledge protection strategies (de Faria and Sofka, 2010), domestic and foreign firms do not appear to differ in their inclinations to patent after accounting for firms' other characteristics. This result does not reject the possibility of institutional duality, but it is suggestive of isomorphism between foreign and domestic firms with respect to patent behavior (controlling for firms' other attributes). Moreover, this finding supports innovation theory in that it explains the patent behavior of firms; that is, the inclination of firms to patent largely depends on the appropriability regime within which they operate (regardless of firms' ownership structures). Thus, our results are consistent with previous results indicating that foreign-controlled firms are more inclined to patent when they either have superior innovative

capacity compared with their domestic counterparts (Costa and de Queiroz, 2002; Kannebley Jr. et al., 2005) or are engaged in global innovation projects (Zhao, 2006).

Given extant knowledge, the above results are not entirely unexpected. They simply suggest that alternative lines of thought may provide a better fit in assessing firms' patenting behavior. However, a somewhat striking finding emerged from our analysis: that patenting and the adoption of novel management practices are not mutually reinforcing. On the contrary, the adoption of novel management practices reduces the likelihood of patenting. Thus, hypothesis 3—that the likelihood of patenting increases with the adoption of new management practices—was rejected. Although we do not test the specific case of innovation-oriented management practices, our results are instructive because, to the best of our knowledge, there has been no effort to date to directly test the effects of the adoption of novel management practices on firms' propensities to patent.

Moreover, the frequent use of patents in more developed economies has led innovation scholars to conclude that the use of patents has a marginal positive effect (Cohen et al., 2000). That is, despite their limited effectiveness, patents can complement other means of appropriation (Graham, 2008). In fact, recent empirical findings pertaining to strong patent systems have largely supported the view that patents complement both formal and informal means of reaping the benefits of innovation (Amara et al., 2008; Gallié and Legros, 2012). Our findings shed new light on the appropriability debate in suggesting not only that management is important (Webster, 2004) but also that better management may be a substitute for patents in reaping the benefits of innovation when firms encounter dysfunctional patent systems. While we have not directly tested this proposition, our results suggest that (all else equal), given weak property rights, firms pursue more sophisticated management practices to compensate for the inefficiencies of the local patent system. Nonetheless, this

behavior occurs at the expense of patenting; that is, when property rights are fragile, firms appear to prefer to capture value by means other than patenting.

To the extent that firms in weaker institutional settings cannot rely on the patent system, they appear to be better off relying on improvements in their managerial capabilities. As the problems that firms have in extracting value from new knowledge are amplified under weak appropriability conditions, they appear to resort to development/ownership of assets/capabilities that will (hopefully) enable them to perform better under such circumstances. To some extent, this finding is aligned with Teece's (1986) 'profiting from innovation' framework. Teece has long recognized that the presence or absence of critical complementary assets affects the prospects for appropriating the gains of innovation when the appropriability regime is weak. One of the central tenets of Teece's 'profiting from innovation' framework is that "[i]n cases where legal protection is weak or nonexistent, the control of cospecialized assets will be needed for long-run survival" (ibid., p. 301). However, the author does not claim that firms attempt to own complementary assets in opposition to patenting. Rather, he argues that when innovators' ability to capture value is dramatically circumscribed due to weak appropriability regimes, access to complementary assets becomes pivotal. While our finding supports Teece's proposition with respect to the importance of complementary assets, it undermines the notion of a tradeoff between patenting and securing complementary assets when appropriability is weak.

As the adoption of new management practices derives from the stock of human capital (Bloom and Van Reenen, 2010), one could argue that our findings reinforce the notion that the stock of human capital negatively moderates the effect of the stock of intellectual capital on the likelihood of patenting (Tzabbar et al., 2008). We contend, however, that an average firm in our empirical setting is unlikely to possess a large stock of human capital. The size of

the long tail of the distribution of the quality of management practices in our empirical setting supports this notion (see Bloom and Van Reenen, 2010). Moreover, among firms participating in the innovation survey that carried out R&D, only 8% of their personnel held masters or DSc/PhD degrees (IBGE, 2005). Moreover, despite their R&D efforts, most of our sample firms are unlikely to be working at the technological frontier - only 2.7% of firms in the sample had introduced a product novel to the national market. Our findings may resonate with the idea that appropriability is a second-order behavior (Moran and Ghoshal, 1999). In the absence of secure property rights, first-order behavior with respect to value creation prevails, and capability development might be instrumental.

## 5. Conclusions

Using firm-level data from the Brazilian Industrial Survey of Technological Innovation (Pintec), this paper has examined whether a firm's propensity to patent is altered when operating in a weak institutional environment. Therefore, our analysis not only builds on standard models of firms' propensities to patent but also contributes to the growing research on emerging markets and the influence of institutional settings on firms' behavior. Controlling for several common explanatory factors, such as a firm's innovative capacity, size, level of government support, industrial sector, and the level of market competition, we focused our investigation on three determinants: partnership, ownership, and management. In short, the present study suggests that a firm's propensity to patent in a weak institutional setting is largely affected by the same factors that explain a firm's propensity to patent in stronger institutional context. However, several remarks are in order. For example, our results indicate that, all else equal, ownership has no effect on a firm's propensity to patent, whereas engagement in innovative collaboration is a critical determinant of this propensity, even if

property rights are difficult to enforce. Additionally, we have shown that the adoption of novel management practices by our sample firms replaced the use of patents.

From a theoretical standpoint, this study contributes to our understanding of firms' patent behavior when firms are confronted by intellectual property rights that are constrained by the rule of law. Even if our findings are based on a specific empirical context (i.e., Brazil), they are likely to be generalizable to other markets where the judicial system is governed by high levels of formalism and low levels of safeguarding against infringements of property rights. In particular, it is usually assumed that firms that establish innovation partnerships exhibit an increased inclination to patent to more effectively exploit new endeavors that emerge from joint efforts and to avoid unintended knowledge spillovers by securing property rights. Our analysis, however, suggests that the latter assumption is questionable when patent protection is weak. While firms in this environment that participate in innovation cooperation are more inclined to patent than firms that do not engage in such cooperation, they do not appear to be less fearful of sharing knowledge as a result of holding patents. Although we do not examine specific governance structures regarding innovation, our finding is consistent with the notion that relational norms promote increased support for the exchange of proprietary information in weak institutional contexts. In addition, our result reinforces the view that despite limited enforceability of formal rules, contractual arrangements are not ignored. Our study, moreover, adds to the literature on international business by suggesting that institutional duality may in fact converge over time to a pattern of behavior suitable to a host country's institutional setting. Although the objective of our paper is not to directly test this concept, the evidence that foreign affiliates do not differ from domestic firms in their propensities to patent suggests that foreign and domestic firms respond similarly to incentives to patent in the focal country, a conclusion that accords with the perspective of innovation theory. Finally, our study adds to a growing body of research on appropriability and builds on

extant knowledge by showing that firms appear to compensate for the dysfunctions of a weak patent system by replacing patents with enhanced management methods. Given that novel management practices can be substitutes for patenting, the remaining questions concern whether and to what extent this behavior could be adopted by firms in institutional contexts more favorable to property rights, contexts that strongly favor patenting (van Zeebroeck et al., 2009).

The managerial implications of our results are clear. Although the ability of patents to prevent knowledge spillovers may be limited in weak institutional settings, and the development of social ties with partners may be critical, managers should not disregard patenting when their firms engage in innovation-based collaboration in such contexts. By partnering, firms are likely to encounter new possibilities for exploration and exploitation upon which proprietary positions can be built. Moreover, for international managers, the findings reinforce the view that, although adaptation to local conditions may not always be desirable, such adaptation is certainly an issue to consider when assessing local institutional arrangements related to IPR. Finally, although patents can be important components of innovators' strategies, our research reveals that their inefficiency, due to institutional weaknesses, motivates firms to pursue alternative means of capturing the returns from innovation, for example, employing more sophisticated management practices.

Our research is admittedly limited in some respects. For example, our understanding of the role of patents in the establishment of partnerships is modest, as is our knowledge of the nature of relational arrangements. Moreover, we could not control for characteristics of partnerships (e.g., whether firms were cooperating with firms they already knew or with new partners). With respect to the effects of ownership, our analysis is based on a very limited picture of firms' appropriation strategies, and we are unable to contrast the countries of origin

of subsidiaries of MNEs (although it is well known that psychic distance affects firms' behavior). Additionally, we do not examine whether the adoption of new management practices is directly related to the innovation process, and our findings are likely affected by the crude definition and metric of management practice employed; we cannot, for example, disentangle the extent to which the replacement of patents by new management practices is guided by firms' interests either in value creation or in value capture. Moreover, a methodological problem suggests the necessity of exploiting the relationship between the adoption of management practices and patents in a lagged structure. Even if our results suggest that decisions to patent and decisions to adopt new management practices are simultaneous, our approach has essentially assumed that the outcomes of the decision set are governed by the same process. The strength of our instrumental variable is also questionable but is limited by the nature of our dataset. In closing, extrapolation of our results should be undertaken with caution, due to the nature of our sample and our timeframe.

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**Table 1**
Definition of control variables used in the empirical analysis

| Control variables | References | Definition |
|---|---|---|
| 1. Firm size | Licht and Zoz (1998); Scherer (1965); Schmookler (1962) | • The logarithm of the number of employees (Ln number employees). |
| 2. Innovative capacity (*ex-ante*) | Cincera (1997); Duguet and Kabla (2000); Hall and Ziedonis (2001) | • The logarithm of the R&D expenses normalized by firm turnover (Ln R&D intensity).<br>• The percentage of a firm's staff educated to the degree level or above in science or engineering was employed to overcome, at least in part, a common criticism of using R&D; that is, smaller firms may be neglected during estimation (% Personnel sci./ eng. Degree). |
| 3. Innovative capacity (*ex-post*) | Cohen (1995); Duguet and Kabla (2000) | • A dummy variable for whether a firm introduced an innovation new to its national market (Product Novelty). |
| 4. Degree of competition | Cohen (1995); Scherer (1983) | • A categorical variable representing the firm's largest market. The reference market is the national market, and the other markets were i) the state in which the firms are located (Brazil is geographically divided into states), ii) the region in which the firms are located (in Brazil, regions are well-defined groups of states), and iii) the international market. |
| 5. Government support | Griliches (1990); Hoskisson et al. (2000) | • A dummy variable to account for the possibility that a firm received any support from the Government. |
| 6. Industry | Scherer (1965, 1983); Teece (1986) | • A series of dummy variables reflecting different market conditions across manufacturing sectors. The reference industrial sector is 'precision instruments' (this is the sector with the largest proportion of patent users in Pintec). |

**Table 2**

Summary statistics and correlation matrix[a,b]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. *Innovation partnerships* | 1.000 | | | | | | |
| 2. *Ownership* | 0.214*** | 1.000 | | | | | |
| 3. *Ln*(*Employees)* | 0.396*** | 0.280*** | 1.000 | | | | |
| 4. *Ln(R&D intensity)* | -0.113*** | -0.154*** | -0.528*** | 1.000 | | | |
| 5. *Product novelty* | 0.252*** | 0.144*** | 0.233*** | -0.001 | 1.000 | | |
| 6. M*arket* | 0.122*** | 0.153*** | 0.235*** | -0.060** | 0.124*** | 1.000 | |
| 7. *Government support* | 0.194*** | -0.026 | 0.127*** | 0.026 | 0.095*** | 0.056** | 1.000 |
| Mean | 0.267 | 1.259 | 5.572 | -4.936 | 0.318 | 2.657 | 0.311 |
| Standard deviation | 0.442 | 0.494 | 1.624 | 1.801 | 0.466 | 0.826 | 0.463 |

[a] ** significant at 5%; *** significant at 1%.

[b] n=1720

**Table 3**
Percentage of firms in Brazilian manufacturing that used appropriability mechanisms

| Mechanism | Total Manufacturing | Product Innovators [a] | Process Innovators [a] |
|---|---|---|---|
| Copyright | 2.05 | 7.15 | 7.34 |
| Complexity | 2.98 | 10.80 | 12.16 |
| Lead-time | 6.41 | 28.76 | 30.96 |
| Utility model | 7.07 | 18.68 | 18.58 |
| Patent | 7.49 | 29.34 | 25.46 |
| Industrial design | 8.39 | 20.58 | 22.48 |
| Secrecy | 14.00 | 39.71 | 42.89 |
| Trademark | 23.02 | 45.40 | 49.31 |

[a] Those that have introduced an innovation novel to the Brazilian market.

**Table 4**
Percentage of firms in Brazilian manufacturing that used patents (by industrial sector)

| Industrial Sector | Patent Users (%) |
|---|---|
| Food, beverages and tobacco | 2.78 |
| Textiles and clothing | 1.47 |
| Wood and furniture | 1.78 |
| Paper and cellulose | 11.02 |
| Chemicals ( incl. drugs) | 13.32 |
| Rubber and plastic products | 10.30 |
| Non metallic | 6.03 |
| Steel, non-ferrous, and casting | 9.70 |
| Basic metals | 5.52 |
| Machinery, except office | 15.98 |
| Office and computing equips. | 17.31 |
| Electrical equipment | 15.22 |
| Communication equipments | 9.17 |
| Precision instruments | 23.71 |
| Motor vehicles | 13.56 |
| Autoparts | 14.50 |
| Other manufacturing | 3.48 |

**Table 5**
The effects of ownership and partnership on firms' propensities to patent in Brazilian manufacturing[a,b]

| **Covariates** | **(M1)** | **(M2)** | **(M3)** | **(M4)** |
|---|---|---|---|---|
| *Innovation partnerships* | 0.609** | 0.570** | 0.702** | 0.679** |
| | (0.308) | (0.283) | (0.309) | (0.284) |
| *Foreign owner* | 0.382 | 0.295 | 0.381 | 0.284 |
| | (0.271) | (0.266) | (0.245) | (0.239) |
| *Domestic & foreign owner* | -0.397 | -0.516 | -0.371 | -0.510 |
| | (0.515) | (0.522) | (0.485) | (0.501) |
| Size (Ln number employees) | 0.456*** | 0.363*** | 0.473*** | 0.349*** |
| | (0.096) | (0.082) | (0.098) | (0.090) |
| R&D intensity (Ln) | 0.228*** | | 0.243*** | |
| | (0.087) | | (0.080) | |
| % Personnel sci./ eng. degree | | 4.967*** | | 4.577*** |
| | | (1.814) | | (2.022) |
| Product Novelty | 1.185*** | 1.265*** | | |
| | (0.229) | (0.231) | | |
| Process Novelty | | | 0.375 | 0.581* |
| | | | (0.286) | (0.346) |
| State market [c] | -0.144 | -0.154 | -0.247 | -0.276 |
| | (0.387) | (0.378) | (0.352) | (0.348) |
| Regional market [c] | -0.267 | -0.385 | -0.333 | -0.458 |
| | (0.379) | (0.361) | (0.348) | (0.337) |
| International market [c] | 0.875** | 0.912** | 0.920** | 0.945** |
| | (0.373) | (0.419) | (0.389) | (0.411) |
| Government support | -0.015 | -0.061 | -0.019 | -0.031 |
| | (0.266) | (0.295) | (0.272) | (0.283) |
| Constant | -3.076*** | -3.778*** | -2.569*** | -3.128*** |
| | (0.528) | (0.538) | (0.542) | (0.537) |
| Industry dummies | Yes | Yes | Yes | Yes |
| *N* | 1720 | 1720 | 1720 | 1720 |
| Log-pseudolikelihood | -1402.56 | -1405.54 | -1464.46 | -1471.76 |
| Model chi-square | 234.10*** | 268.32*** | 233.18*** | 250.98*** |
| McFadden's pseudo R2 | 0.2006 | 0.1989 | 0.1654 | 0.1612 |
| BIC | 3006.26 | 3012.24 | 3130.08 | 3144.68 |
| AIC | 2859.11 | 2865.09 | 2982.93 | 2997.52 |
| Correctly classified (%) | 84.94 | 84.48 | 83.72 | 84.13 |

[a] Robust standard errors in parentheses.
[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.
[c] The reference market is the local one.

**Table 6**
The effects of the adoption of organizational changes on firms' propensities to patent in Brazilian manufacturing[a,b]

| **Covariates** | **(M5)** | **(M5) dy/dx [d]** | **(M6)** | **(M7)** |
|---|---|---|---|---|
| *New mngt. practices* | -0.593** | -0.045** | | |
| | (0.258) | (0.020) | | |
| *Strategy re-alignment* | | | -0.233 | |
| | | | (0.231) | |
| *New org. structure* | | | | 0.004 |
| | | | | (0.244) |
| *Innovation partnerships* | 0.639** | 0.049** | 0.633** | 0.609** |
| | (0.309) | (0.025) | (0.308) | (0.307) |
| *Foreign owner* | 0.486* | 0.037* | 0.405 | 0.381 |
| | (0.274) | (0.021) | (0.270) | (0.272) |
| *Domestic & foreign owner* | -0.301 | -0.023 | -0.366 | -0.397 |
| | (0.516) | (0.040) | (0.511) | (0.517) |
| Size (Ln number employees) | 0.499*** | 0.038*** | 0.469*** | 0.456*** |
| | (0.098) | (0.006) | (0.095) | (0.098) |
| R&D intensity (Ln) | 0.242*** | 0.018*** | 0.234*** | 0.228** |
| | (0.085) | (0.006) | (0.086) | (0.087) |
| Novelty of innovation | 1.260*** | 0.097*** | 1.190*** | 1.185*** |
| | (0.228) | (0.017) | (0.229) | (0.229) |
| State market [c] | -0.135 | -0.010 | -0.158 | -0.144 |
| | (0.376) | (0.029) | (0.392) | (0.385) |
| Regional market [c] | -0.216 | -0.016 | -0.263 | -0.268 |
| | (0.385) | (0.030) | (0.380) | (0.380) |
| International market [c] | 0.910** | 0.070** | 0.861** | 0.875** |
| | (0.370) | (0.028) | (0.368) | (0.373) |
| Government support | -0.004 | -0.0003 | -0.003 | -0.016 |
| | (0.254) | (0.019) | (0.264) | (0.277) |
| Constant | -2.937*** | | -3.072*** | -3.077*** |
| | (0.526) | | (0.537) | (0.529) |
| Industry dummies | Yes | | Yes | Yes |
| *N* | 1720 | | 1720 | 1720 |
| Log-pseudolikelihood | -1388.02 | | -1400.60 | -1402.56 |
| Model chi-square | 229.93*** | | 234.29*** | 234.40*** |
| McFadden's pseudo R2 | 0.2089 | | 0.2018 | 0.2006 |
| BIC | 2984.65 | | 3009.81 | 3013.71 |
| AIC | 2832.05 | | 2857.21 | 2861.11 |
| Correctly classified (%) | 84.94 | | 84.94 | 84.94 |

[a] Robust standard errors in parentheses.
[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.
[c] The reference market is the local one.
[d] Marginal effects (model 5).

**Table 7**
Bivariate binary probit model estimates[a,b]

| Covariates | Patent (M8) | Mngt Practices (M9) |
|---|---|---|
| Innovation partnerships | 0.356** | 0.256* |
| | (0.157) | (0.156) |
| Foreign owner | 0.219 | 0.592*** |
| | (0.143) | (0.271) |
| Domestic & foreign owner | -0.211 | 0.676* |
| | (0.256) | (0.515) |
| Size (Ln number employees) | 0.248*** | 0.178*** |
| | (0.048) | (0.047) |
| R&D intensity (Ln) | 0.118*** | 0.052 |
| | (0.042) | (0.038) |
| Product Novelty | 0.627*** | 1.291** |
| | (0.120) | (0.146) |
| State market [c] | -0.049 | -0.179 |
| | (0.182) | (0.148) |
| Regional market [c] | -0.152 | 0.272 |
| | (0.193) | (0.178) |
| International market [c] | 0.458** | 0.104 |
| | (0.215) | (0.301) |
| Government support | -0.045 | 0.113 |
| | (0.135) | (0.132) |
| Constant | -1.745*** | -0.739*** |
| | (0.282) | (0.325) |
| Industry dummies | Yes | |
| *N* | 1720 | |
| Log-pseudolikelihood | -4611.32 | |
| Model chi-square | 378.38*** | |
| BIC | 9632.40 | |
| AIC | 9332.64 | |
| ***ρ*** | ***-0.170**** | |

[a] Robust standard errors in parentheses.
[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.
[c] The reference market is the local one.

**Appendix 1**

Logit estimates of firms' propensity to patent[a,b]

| **Covariates** | **(A1.1)** | **(A1.2)** | **(A1.3)** | **(M1)** |
|---|---|---|---|---|
| *Innovation partnerships* | | 0.642** | | 0.609** |
| | | (0.298) | | (0.308) |
| *Foreign owner* | | | 0.447* | 0.382 |
| | | | (0.257) | (0.271) |
| *Domestic & foreign owner* | | | -0.389 | -0.397 |
| | | | (0.496) | (0.515) |
| Size (Ln number employees) | 0.548*** | 0.480*** | 0.515*** | 0.456*** |
| | (0.086) | (0.097) | (0.086) | (0.096) |
| R&D intensity (Ln) | 0.234*** | 0.225*** | 0.238*** | 0.228*** |
| | (0.087) | (0.087) | (0.086) | (0.087) |
| Product Novelty | 1.238*** | 1.190*** | 1.230*** | 1.185*** |
| | (0.222) | (0.229) | (0.222) | (0.229) |
| State market [c] | -0.150 | -0.156 | -0.137 | -0.144 |
| | (0.385) | (0.386) | (0.385) | (0.387) |
| Regional market [c] | -0.277 | -0.280 | -0.263 | -0.267 |
| | (0.374) | (0.375) | (0.379) | (0.379) |
| International market [c] | 0.926** | 0.912** | 0.877** | 0.875** |
| | (0.370) | (0.375) | (0.369) | (0.373) |
| Government support | -0.001 | -0.056 | -0.044 | -0.015 |
| | (0.245) | (0.259) | (0.251) | (0.266) |
| Constant | -3.362*** | -3.154*** | -3.257*** | -3.076*** |
| | (0.507) | (0.526) | (0.511) | (0.528) |
| Industry dummies | Yes | Yes | Yes | Yes |
| *N* | 1720 | 1720 | 1720 | 1720 |
| Log-pseudolikelihood | -1418.11 | -1406.56 | -1412.74 | -1402.56 |
| Model chi-square | 196.96 | 222.99*** | 207.43*** | 234.10*** |
| McFadden's pseudo R2 | 0.1918 | 0.1984 | 0.1948 | 0.2006 |
| BIC | 3015.03 | 2999.37 | 3019.19 | 3006.26 |
| AIC | 2884.22 | 2863.12 | 2877.50 | 2859.11 |

[a] Robust standard errors in parentheses.

[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.

[c] The reference market is the local one.

**Appendix 2**

Logit estimates of firms' propensity to patent – alternative proxies and augmented model[a,b,c]

| **Covariates** | **(A2.1)** | **(A2.2)** | **(A2.3)** | **(A2.4)** |
|---|---|---|---|---|
| Innovation partnerships | 0.605** | 0.618** | 0.548** | 0.595** |
| | (0.307) | (0.291) | (0.250) | (0.305) |
| Foreign owner | 0.372 | 0.347 | 0.194 | 0.379 |
| | (0.270) | (0.267) | (0.244) | (0.273) |
| Domestic & foreign owner | -0.396 | -0.518 | -0.579 | -0.402 |
| | (0.514) | (0.524) | (0.446) | (0.509) |
| Size (Ln) | 0.438*** | 0.396*** | 0.308*** | 0.442*** |
| | (0.095) | (0.092) | (0.087) | (0.109) |
| R&D intensity (Ln) | **0.208*** ** | **0.186** ** | | 0.229*** |
| | **(0.087)** | **(0.092)** | | (0.086) |
| % Personnel sci./ eng. Degree | | | **5.625*** ** | |
| | | | **(2.105)** | |
| Product Novelty | 1.190*** | 1.211*** | 1.821*** | 1.176*** |
| | (0.229) | (0.230) | (0.276) | (0.227) |
| State market [d] | -0.144 | -0.150 | -0.329 | -0.131 |
| | (0.386) | (0.389) | (0.305) | (0.387) |
| Regional market [d] | -0.264 | -0.278 | -1.092*** | -0.264 |
| | (0.380) | (0.378) | (0.316) | (0.378) |
| International market [d] | 0.875** | 0.853** | 0.530 | 0.885** |
| | (0.376) | (0.375) | (0.492) | (0.373) |
| Government support | -0.020 | -0.043 | -0.372 | -0.023 |
| | (0.268) | (0.265) | (0.268) | (0.263) |
| Group | | | | **0.184** |
| | | | | **(0.241)** |
| Age | | | | **-0.0005** |
| | | | | **(0.0108)** |
| Constant | -3.091*** | -3.108*** | -3.873*** | -3.005*** |
| | (0.530) | (0.540) | (0.497) | (0.826) |
| Industry dummies | Yes | Yes | Yes | Yes |
| *N* | 1720 | 1720 | 4731 | 1720 |
| Log-pseudolikelihood | -1406.50 | -1409.82 | -3167.92 | -1401.77 |
| Model chi-square | 233.08*** | 226.47*** | 470.64*** | 234.74*** |
| McFadden's pseudo R2 | 0.1984 | 0.1965 | 0.2374 | 0.2011 |
| BIC | 3014.15 | 3020.79 | 6564.32 | 3019.60 |
| AIC | 2866.99 | 2873.64 | 6389.85 | 2861.55 |

[a] Robust standard errors in parentheses.

[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.

[c] Model A2.4 is an augmented model, and bold estimates in models A2.1 to A2.3 represent alternative proxies, where R&D is proxied either by internal and external expenses (A2.1) or by the total amount spent on innovation – internal and external expenses plus equipment, software, training, launching and distribution expenses (A2.2); and % Personnel sci./ eng. Degree is not constrained by R&D respondents (A2.3).

[d] The reference market is the local one.

## Appendix 3

Bivariate probit endogeneity test[a,b,c]

| Covariates | Patent | Innovation Partnership |
|---|---|---|
| Innovation partnerships | -0.323 | |
| | (0.421) | |
| Foreign owner | 0.293** | 0.327*** |
| | (0.144) | (0.098) |
| Domestic & foreign owner | -0.186 | -0.067 |
| | (0.242) | (0.210) |
| Size (Ln number employees) | 0.294*** | 0.283*** |
| | (0.058) | (0.060) |
| R&D intensity (Ln) | 0.113*** | -0.016 |
| | (0.040) | (0.049) |
| Product Novelty | 0.703*** | 0.527*** |
| | (0.131) | (0.166) |
| State market [c] | -0.025 | 0.248 |
| | (0.202) | (0.177) |
| Regional market [c] | -0.122 | 0.183 |
| | (0.206) | (0.207) |
| International market [c] | 0.493** | 0.314 |
| | (0.207) | (0.193) |
| Government support | -0.016 | 0.278*** |
| | (0.140) | (0.101) |
| Instrumental variable: | | 0.360** |
| *important external source* | | (0.145) |
| Constant | -1.958*** | -0.739*** |
| | (0.323) | (0.325) |
| Industry dummies | Yes | |
| *N* | 1720 | |
| Log-pseudolikelihood | -3071.57 | |
| Model chi-square | 481.78*** | |
| BIC | 6552.90 | |
| AIC | 6253.15 | |
| ***ρ*** | ***0.391***[†] | |

[a] Robust standard errors in parentheses.

[b] * Significant at 10%; ** significant at 5%; *** significant at 1%.

[c] The reference market is the local one.

[†] Not statistically significant (chi2(1) = 2.155).