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Institutions and the direction of innovative search: Change and persistence between and within countries

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Abstract

This paper examines the impact of the macro-institutional environment on exploitative-explorative innovation. Building on organizational learning, institutional economics, and innovation studies, we identify country-level institutions that might foster or hinder firms' incentives and ability to explore or exploit. We test our conjectures by analyzing all patented firm innovations in 22 countries over the 1985-2008 timeframe. Empirical tests demonstrate the role of national institutions in explaining cross-country differences in the level of exploitative and exploratory innovation. The results also suggest that firms' incentives to explore are influenced by changes in the institutions that regulate the ecology of competition in an economy.

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INTRODUCTION

Two organizational learning processes are considered the primary drivers of technological innovations within firms: exploitation, or local search and refinement of a firm's knowledge base, and exploration, or distant search and experimentation with new knowledge. Each process is a viable way for organizations to increase their innovation output. There are, however, substantial differences in the resource-allocation decisions and organizational routines required to pursue these activities, as well as in their long-term performance implications. Accordingly, identifying the factors that lead to tendencies to either explore or exploit has been an important theme of research.

Prior empirical work in this area has primarily considered 'micro-level factors'—the individual and organizational determinants of exploration-exploitation. However, a fundamental premise in the literature is that a firm's search effort depends on the social context of learning (March, 1991; Ghemawat & Ricart Costa, 1993). Further, theoretical studies have also suggested that social contexts required for undertaking exploratory or exploitative innovation are embedded in specific country-level institutions (Levinthal and March, 1993; Lewin, Long & Carroll, 1999). Nonetheless, there have been no attempts to describe the effects of institutions on exploration-exploitation or to estimate their magnitude. The few efforts to understand the environmental antecedents of organizational search processes have focused on theoretical simulations (Lant & Mezas, 1992; Kim and Rhee, 2009; Posen & Levinthal, 2012) and surveys of managers' perception of external threats (Sidhu, Commandeur & Volberda, 2007; Jansen, Van Den Bosh & Volberda, 2006; Voss, Sirdeshmukh & Voss, 2008). In this line of research, environmental factors have been conceptualized primarily in terms of 'dynamism', 'turbulence', and 'competitive intensity', whereas regulatory institutions have been largely ignored.

This study seeks to redirect attention to the macro-institutional effects on the innovation search process. Building on the theoretical framework pioneered by March (1991), we argue that social contexts conducive to exploration or exploitation are shaped by specific institutions that characterize contemporary political economies. We draw on institutional economics, innovation studies, and organizational learning to further propose that the country-level institutions in the education, labor, finance, and corporate control markets may either foster or hinder the ability of firms to engage in exploration and exploitation. We test

our hypotheses by analyzing all inventions generated by business corporations in 22 countries and protected by patents filed with the three major patent offices in the world between 1985 and 2008. Underlying our empirical methodology is the premise that a long-term tendency of the institutional environment to create favorable conditions for a particular search direction will produce distinctive patterns of innovation outputs at the country-level (Nelson & Rosenberg, 1993).

This is the first study of which we are aware that responds to a recent call by Lavie, Stettner and Tushman (2010:142) to examine “cross-national differences in organizations’ tendency to explore or exploit”. The empirical tests strongly demonstrate the role of national-level institutions in shaping the extent to which firms engage in exploitation and exploration. We find higher levels of exploitation in countries where the educational system sustains higher levels of firm- and-industry specific skills and in countries where the institutional environment puts less competitive pressure on firms (such as less active markets for corporate controls or bank-based rather than market-based financial systems). Conversely, general-skills educational systems, flexible labor markets, and institutional environments that put strong competitive pressure on firms lead firms to pursue exploratory innovation.

Our empirical approach captures the subtle ways in which institutional effects operate across countries and over time. Most of the variation in the levels of exploitation occurred across countries and was produced by enduring, cross-country differences in the educational systems and in the institutions governing the competitive pressure on firms. However, within any given country, firms’ strategies of local search were very little affected by institutional change. On the contrary, most of this variation in exploratory innovation can be explained by changes in the firm search behavior due to country-specific changes in the national labor market, the market for corporate control, and the financial system.

The approach taken in this paper and the empirical patterns that we uncovered have a number of implications for our understanding of the institutional determinants of exploration-exploitation, and more broadly, firm innovation behavior. These implications can be summarized along four main contributions. First, we contribute to the literature on innovation search, showing that institutions have an important, but nuanced effect on both exploitation and exploration. Second, we contribute to the literature that aims to uncover the way in which institutional and structural characteristics of countries influence organizational

processes and firm performance levels, providing evidence that country-level institutions provide firms with advantages in their exploration or exploitation efforts by shaping the supply of inputs available to firms and incentivizing firms to engage in certain activities by rewarding those that are socially desirable. Third, we advance theory and managerial practice regarding the optimal location of innovative activities by moving beyond the characterization of institutions as promoting or impeding innovation, indicating that the optimal location of R&D activities is highly contingent on the desired goal of those activities. Finally, we demonstrate the applicability of an empirical modeling approach that, combined with a novel and comprehensive data set, allows researchers to separate the effects of cross-temporal and cross-country variation in institutions.

THEORY AND PREDICTIONS

Research looking at technological innovation through the lenses of exploration and exploitation depicts innovation as a problem-solving process in which solutions to technological problems are discovered via search across various domains of knowledge (Fleming, 2001). Local search innovation processes combine familiar sets of technology components or refine previously used combinations of knowledge components. Distant search innovation processes involve either new combinations of known components or completely new components.

Each strategy enables the development of new products (Katila & Ahuja, 2002; Rosenkopf & Nerkar, 2001). However, the underlying knowledge recombination processes build on distinct routines, resources, organizational structures, and risk taking behavior. For example, exploitation is dependent on such factors as continuous organizational efforts toward efficiency improvement (Benner & Tushman, 2002), the ability of a firm to develop a deep, firm-specific knowledge base (Katila & Ahuja, 2002), and an organizational structure that favors rapid socialization of individuals into firm's existing routines (March, 1991). Exploration requires organizations to develop new capabilities, to encourage knowledge variety, and to engage in experimentation and risk taking (Levinthal & March, 1993; O'Reilly & Tushman, 2008; Kim & Rhee, 2009).

Management scholars seeking to understand why some firms successfully search in one direction or another have devoted a great deal of attention to the individual and organizational determinants of

search strategy. Fewer studies have examined the environmental antecedents of exploration and exploitation (Lavie et al., 2010). Common to existing efforts in this direction is conceptualizing the external environment drawing from the evolutionary theory of the firm, which emphasizes the adaptation responses of organizations faced with changing external conditions. Formal simulation approaches have looked at the influence of environmental turbulence (e.g., Lant & Mezias, 1992; Posen & Levinthal, 2012) and dynamism (e.g. Kim & Rhee, 2009; Fang, Lee & Schilling, 2010) on exploration-exploitation. There is limited empirical evidence on how these features of the environment affect organizational search. Notable exceptions include Jansen et al. (2006), who found that exploitation is more beneficial in competitive environments while exploration is more effective in dynamic environments; Sidhu et al. (2007), who examined the payoffs from various boundary-spanning exploration activities in relation to various levels of environmental dynamism; and Voss et al. (2008) who showed that the allocation of resources to exploration or exploitation depends on the degree to which organizations perceive the environment as threatening. Evidence in these studies came from cross-sectional data and was based on subjective perceptions of the environment derived from survey responses. Whether and to what extent environmental pressures lead to organizational tendencies to explore or exploit have not been subject to empirical investigation, although they remain central issues in theoretical research. We address these questions here.

We develop theory based on March's (1991) original argument that exploration-exploitation behavior is an adaptation response to the social context of learning. We conceptualize the environment in March's simulations through the lenses of institutional theory, where the focus is on the macroeconomic, political, legal and social institutions within which firms and industries are embedded. Our approach follows a research tradition that aims to understand the influence of regulatory institutions on firms' strategic choices (e.g., Lewin et al. 1999; Kogut, Walker & Anand, 2002; Capron & Guillen, 2009; Frank, 2013). Our goal is to provide econometric evidence of the extent to which behavioral tendencies favoring one type of innovation search can be explained as an adaptation response to regulatory institutions operating at the national level.

As noted by March (1991) and subsequent work, exploration-exploitation processes are driven by both *explicit* and *implicit* considerations. The choice of investing in a technological direction can be a calculated managerial decision based on a comparison of the expected economic returns of taking a specific technological path with those of alternative investments. Existing research on organizational and individual antecedents of exploration-exploitation has made important progress in understanding these ‘explicit’ choices. At the same time, the choice between exploration and exploitation can be a manifestation of a more pervasive organizational adaptation to the environment (Ghemawat & Ricart Costa, 1993; Levinthal & March, 1993; March 1991). Within this perspective, macroregulatory institutions are part of the environment to which the firm is adapting, and lie beneath the implicit organizational choices (Lewin et al., 1999; Kogut et al., 2002).

We argue that institutions have a direct, first-order effect on intra-organizational socialization and inter-organizational competition — the main foundations for exploration and exploitation behavior in March’s (1991) model of organizational learning. Intra-organizational socialization refers to the mutual learning process through which individuals assimilate an organization’s ‘code’, i.e. language, beliefs, and practices (March, 1991:74), and the organization learns from the informational input provided by its members. Socialization processes are important because they determine the diversity in the pool of knowledge that organizations can draw upon. Inter-organizational competition describes the degree to which firms are rewarded for a reliable increase in the average performance or, on the contrary, for being among the highest performing competitors. The ecology of competition shapes performance aspiration levels in an economy, which in turn influence organizational incentives for risk taking.

By linking formal institutions with these two features of the social context we propose that institutional effects on exploration-exploitation are related to the combination of two main mechanisms. On the one hand, institutions affect the *supply* of inputs, such as the knowledge assets, the financial resources, and the organizational practices that firms could rely on in the innovation search process. Thus, different institutions create different opportunities and impose different costs on exploration-exploitation. On the other hand, institutions provide rewards and penalties for experimentation and risk-seeking

behavior. In this way, institutions operate at the level of *incentives* that prompt managerial action and strategic investments in exploration and exploitation.

HYPOTHESES

Intra-organizational Processes of Socialization

Effective socialization facilitates fast employee integration and behavioral consistency within an organization. However, socialization processes also reduce the variation within the pool of individual knowledge that the organization can appropriate. As a result, social contexts that encourage rapid socialization foster local search and reliability, but reduce organizational incentives for experimentation. Conversely, employee turnover and selection and retention procedures designed to increase the diversity of knowledge in the organization enable exploration.

Managers can take various actions to influence socialization processes within organizations. In addition, we argue that country-level institutions mediate managerial intervention. We suggest that educational and training systems (such as skill-formation policies) and labor market regulations (such as policies of employee mobility, hiring-firing, and wage-setting rules) directly influence the key parameters—socialization rate and turnover—that describe the relationship between intra-organizational processes of learning and exploration-exploitation behavior.

Educational system. Educational systems around the world vary greatly in their approach to skills formation and employee training (Luo, 2007). Relevant for our analysis is the distinction between ‘general’ skills and more ‘specific’ (firm or industry) skills (Estevez-Abe et al., 2001; Iversen & Soskice, 2001; Herrmann & Peine, 2011). General skills systems sustain educational policies that encourage and reward general scholarly achievements (e.g., university and post-graduate qualifications). In these systems, skills are recognized by all employers and “carry a value that is independent of the type of firm or industry” (Estevez-Abe, et al., 2001:148). Systems that sustain ‘firm-specific’ or ‘industry-specific’ skills are characterized by educational policies that encourage on-the-job apprenticeship and vocational school education. Specific skills are acquired through an organized training system that requires substantial involvement from companies, which either directly provide employee training or participate in employer associations that facilitate vocational school education. Investments by the private sector signal

a high level of commitment to sustaining specialized occupational skills and incentivize individuals to acquire skills that tie them to a specific employer or limit their future employment options. In these circumstances, it would be very costly for individuals or firms to deviate from the types of skills that are taught in the educational institutions.

March's model suggests that exploitation processes are facilitated by institutional environments that allow companies to recruit a labor force with high levels of firm- or industry-specific technical skills. Employees with these skills typically develop in-depth knowledge in the same field and have longer tenure with the same organization. Even when they change employment, individuals continue to work in the same industry and bring proximate knowledge to the new organization. Thus, organizations operating in these environments have less opportunities to draw from a heterogeneous pool of outside knowledge. New recruits typically socialize rapidly into the organization's procedures and beliefs, leading to fewer possibilities for organizations to learn from the new members, but helping them reinforce existing competencies.

Educational systems in which individuals acquire general skills are less likely to foster exploitation. General skills are more portable. Individuals who invest in these skills are less dependent on the organization where they work and they can acquire diverse experience by changing jobs. Thus, this type of educational systems does not limit an individual's knowledge to one specific industry. Furthermore, in countries where firms or industries do not provide support for education in specific skills, individuals prefer to obtain general skills (Estevez-Abe et al., 2001). From the employer's perspective, the predominance of workers with general skills in an economy increases the cost of training new workers in specific skills or providing them with adequate incentives to invest in such skills. On the other hand, it also reduces the cost to the firms of losing or replacing employees, which in turn facilitates personnel turnover. Thus, in these contexts, we expect relatively slow socialization of new organizational members into the firm and higher variability in the knowledge background of new recruits. According to March, both mechanisms are important sources of organizational exploration. We thus propose the following hypothesis:

H1a: Educational systems characterized by a higher incidence of training in firm- and industry-specific skills encourage exploitation.

H1b: Educational systems characterized by a higher incidence of general-skills training encourage exploration.

Labor regulations. Personnel turnover is a key parameter in organizational learning because it allows organizations to maintain a certain degree of knowledge variability that is necessary for avoiding the competency trap (Levinthal and March, 1993). Labor regulations institutions are critical in this regard. In countries where labor institutions permit easy hiring and firing of individual workers, firms may benefit from bringing in individuals with different types of knowledge. In turn, the flow of new knowledge into firms is an important precursor to the creation of novel recombination, which characterizes exploration processes. Studies of employee mobility provide strong evidence for these statements. Song, Almeida & Wu (2003) and Singh & Agrawal (2011) showed that knowledge may be transferred across firms through hiring specialized employees—engineers and inventors—from the competition. Further, Rosenkopf and Almeida (2003) found a direct link between employee mobility and effective exploration. Taken together, these findings suggest that flexible labor markets facilitate access to new knowledge, and thus, enable firms to pursue effective exploration.

On the other hand, industrial relations characterized by strict labor regulations reduce the possibility of poaching on other firms' skilled workers and lead to longer job tenure (Estevez-Abe et al., 2001; Bassanini and Ernst, 2002). Thus, firms operating under strict labor regulations are more likely to rely on the internal labor market in the innovation process. This leads to a greater focus on exploitation for two reasons. First, organizations are more likely to draw from a homogenous knowledge base. Second, given the high risk of failure in exploration, companies might be reluctant to pursue exploratory innovation if ex-post labor adjustments (downsizing or reshuffling of personnel) are hindered by labor market restrictions (Bassanini and Ernst, 2002). Hence, we propose the following hypothesis:

H2a. Labor markets characterized by higher rigidity encourage exploitation

H2b. Labor markets characterized by higher flexibility encourage exploration.

Inter-organizational Competition

In March's (1991) framework, exploration and exploitation are also determined by the nature of inter-organizational competition. Organizations can either be in competition for primacy or in an environment where the objective is to avoid relatively low positions. When the key to success is being among the highest performing competitors, organizations must pursue activities that increase the variance of expected performance to create the potential for 'leap-frogging' the competition. Exploration is the preferred learning strategy in these contexts. In contrast, when success in competition is determined by avoiding being among the lowest performing competitors, high variance in performance has negative effects on survival. A reliable increase in the mean performance is then optimal, leading firms towards efficiency and cumulative, incremental technological improvements. These arguments imply that the ecology of competition in an economy provides fundamental incentives for firms to invest in either exploration or exploitation. The foregoing discussion suggests that macro-level factors that regulate inter-firm competition and those that influence risk-taking behavior, such as the market for corporate control and financial institutions, affect the direction of innovation in organizations.

Market for corporate control. Prior research suggests that the competitive pressure on firms is higher in economies with active markets for corporate control, particularly when companies are under the threat of hostile takeovers. Two effects are in play. On the one hand, the market for corporate control acts as an external disciplinary mechanism when top management teams perform poorly and other internal corporate governance mechanisms fail in their monitoring role. Hostile takeovers, in particular, are considered an important instrument that corrects for opportunistic managerial behavior. But in addition to having a disciplinary effect on poorly performing firms, hostile takeovers have another subtle, but crucial role in the managerial labor market (Jensen & Ruback, 1983). Hostile takeovers pit management teams against each other for the right to manage assets owned by shareholders. As Martynova & Renneboog (2008:26) explain, hostile takeovers are designed to attribute the right to manage the assets of a corporation to the team that offers the highest value to the shareholders "until it is replaced by another management team that discovers a higher value of the assets". Thus, in environments with a high threat of hostile takeovers, managers not only face a high likelihood of being removed from the market if they do not perform well,

but also have to compete harder and manage corporate resources better than potential competitors (Jensen & Ruback, 1983).

These arguments suggest that the relative position within a group of competing firms is important in the ecology of competition when firms face the threat of hostile takeover. This dynamics puts pressure on firms to seek opportunities for exceptionally high returns, such as those from exploratory innovation. While strategies for improving performance dramatically are typically risky and may eventually lead to substantially poorer performance, the payoffs in highly active markets for corporate controls are such that severely reduced performance yields only a small downside relative to mediocre performance.

In contrast, a low threat of hostile takeovers means that managers face less demands to improve the short-term performance of the firm. Increasing firm's performance reliably over time is preferred to strategies involving high variance. We posit that these contexts create incentives for organizations to exploit their existing knowledge rather than to engage in risk-taking strategies. Hence:

H3a. Less active markets for corporate control encourage exploitation.

H3b. More active markets for corporate control encourage exploration.

Market and bank-based institutions. The financial structure of an economy, market or bank-based, also influences whether organizations pursue a high-risk high-reward innovation strategy or focus on innovations that increases performance reliability. Stock markets are typically seen as having a positive role in creating incentives for firms to pursue riskier innovation projects. More often than not, financing innovation projects requires evaluating a firms' intangible assets (R&D programs, new technologies, know-how, etc.) and market-based systems have an informational advantage in this regard (Rajan and Zingales, 2003). Indeed, market-based systems have specialized instruments to evaluate these projects, such as equity funds and underwriters. In addition, even if a risky project is rejected by some investors, it is in the nature of markets that investors investigate the firm's prospects independently. Thus, as Rajan and Zingales (2003:21) state, "the firm gets a number of chances to attempt to convince investors of the merits of its technology".

Not only do market-based systems provide the necessary capital for risky projects, they also bestow huge rewards to successful firms. Even if many projects fail, a single blockbuster innovation

enables an innovator to raise high amounts of funds through public offerings. Thus, market-based systems promote successful outcomes and downplay the downside risk. March and Levinthal (1993) identify suggest this context influences organizational incentives towards engaging in riskier behavior.

Conversely, in environments that use reputational monitoring, such as those characterized by the predominance of bank credit, firms have limited chances to obtain resources for developing technologies that depart from the known paths (Aoki, 2000). In these financial systems, credit allocation relies on information generated through direct contracts between banks and borrowers rather than being publicly generated through collective assessment by many investors from a variety of backgrounds. This process allows capital lenders to probe deeper and filter out projects they deem likely to fail. The financing process is typically biased towards conservative projects: it seeks to minimize the cost of funding failures even if the payoffs from funding successful projects are likely to be small. In short, lenders privilege less risky projects, such as those relying on technologies that are already tested and require only incremental improvement, and may reject worthwhile innovations if they are considered to be too risky or cannot be properly evaluated by the lender. Furthermore, lenders and borrowers in such systems customarily have strong and stable relationships, including ownership ties. While lenders have the incentives to monitor management action to protect their interests, they also tend to make long-term commitments once funding is provided (Rajan & Zingales, 1998), insulating firms from both competition (Black & Strahan, 2002), and the pressure to maximize short-term profit. Hence, the competitive environment in bank-based economies stimulates firms to focus on maintaining a performance level that is ‘good enough’ to respect their obligations with capital providers, but firms do not necessarily seek primacy. Exploratory innovation becomes less important in these contexts and also disproportionately expensive, as firms will have to rely on internal financing or to accept prohibitively expensive loans. Thus, these institutional contexts are consistent with firms focusing more on innovations that are incremental as opposed to ‘revolutionary’ (Rajan & Zingales, 2003) or exploratory (Hoskisson, Yiu & Kim, 2004). Therefore:

H4a. Bank-based financial institutions encourage exploitation.

H4b. Market-based financial institutions encourage exploration.

DATA AND EMPIRICAL APPROACH

Following prior literature, we studied the results of organizational search processes by examining the content of firms' innovations. We test our hypotheses using all patents filed and invented by business corporations in 22 countries during the 1985-2008 period. These 22 countries include all current members of OECD except former communist East-European countries and Israel, which had extensive missing or unreliable information, particularly from the 1980s. Ireland enters the data in 1994 with the creation of an independent Irish stock exchange. All countries in the sample have strong legislation on and enforcement of intellectual property rights, as well as consistent information on patent applications. Collectively, these countries generated the majority of patented innovations around the world (De Rassenfosse, Dernis, Guellec, Picci & Poterie, 2013).

Our main source of data on patents was the 2012 edition of the Worldwide Patent Statistical Database (PATSTAT). The final list of inventions analyzed here was obtained through several steps. We used the recently developed OECD HAN database to get a list of distinct, harmonized names of patent assignees. This database is the result of a fairly exhaustive attempt to harmonize patent applicant names for a wide-range of countries, including all 22 countries of interest here (Thoma, Torrisi, Gambardella, Guellec, Hall & Harhoff, 2010). The OECD HAN database provides reliable information on patent applications filed at the three major patent offices in the world: the U.S. Patent Office (USPTO), the European Patent Office (EPO), and the World Intellectual Property Organization (WIPO). To take advantage of the harmonized assignee names, we followed a common practice in large-scale, patent-based cross-country comparative studies (Martinez, 2010) and restricted the list of unique HAN identifiers to those 926,002 assignees that filed at least one patent application with any of these three major offices. Next, we used the patentee sector allocation scheme available from ECOOM-EUROSTAT-EPO PATSTAT Person Augmented Table (Du Plessis, Van Looy, Song & Magerman, 2009; Magerman, Grouwels, Song & Van Looy, 2009; Peeters, Song, Callaert, Grouwels & Van Looy, 2009) to narrow the list of HAN assignees to business corporations, thus identifying 462,170 unique patent assignees.

While most prior research has equated a patent application with an invention, it is well understood in the literature that the same invention can be described by multiple applications. For example, the

original patent application (known as the ‘priority application’) may be followed by ‘domestic continuations’, which add new invention disclosures or claims. Patent applicants often protect the same invention by a series of filings both in the home country patent office and abroad. In essence, all these subsequent filings depict the same invention and counting them separately would falsely inflate the number inventions. The best way to deal with these issues is to focus on patent families rather than patent applications (Martinez, 2010).

There are several methods for defining a patent family. A widely used approach is the INPADOC patent family methodology available in PATSTAT. INPADOC defines an invention as the collection of patent applications directly or indirectly linked through the same priority or combination of priorities (Martinez, 2010). By applying this procedure, we consolidated 28,667,745 patent applications belonging to our list of corporate applicants into 4,346,055 patent families (inventions).

The final dataset consists of 3,283,124 unique inventions filed by 370,527 corporate applicants. We repeated the procedure of aggregating patent applications at INPADOC family level for all forward citations made *to* and all backward citations made *by* the members of focal families in our list.

Lastly, we assigned inventions to countries based on the location of patent inventors (regardless of the patent offices in which the inventions were filed or the assignee location). We dealt with missing or partial information on the location of inventors per De Rassenfosse et al. (2013) and weighted INPADOC families with inventors in multiple countries proportionally to the number of distinct inventor countries per family.

This data set has two novel features. First, we draw from a more comprehensive source of patented inventions than past studies, which typically analyzed patents from a single office. Second, by combining patents and their citations at patent-family level, we take into account all versions of the same invention across various patent offices. This allows us to obtain an accurate count of distinct inventions filed by corporate innovators around the world, minimizing measurement error introduced by using information from patent offices with different citation practices.

Dependent Variables

Following prior research, we relied on technological classes and citations made by patents to prior art to determine the degree to which patented inventions drew from broader or more localized search. All measures of innovation search closely follow prior work in the innovation search literature and were calculated first at INPADOC-family level and, unless otherwise noted, they took into account the assignee-firm past search behavior. We then averaged all invention-level values in a country-year. We constructed separate measures for exploration and exploitation (See Gupta et al. (2006) for a cogent discussion of exploration and exploitation as orthogonal search activities).

The first dependent variable captures the extent to which an invention is the outcome of organizational exploitation. Our measure is the proportion of backward citations to the assignee's own prior patents in a given patent. This variable, which is referred to in the literature as 'internal focus' (Sorensen and Stuart, 2000) or 'local search' (Rosenkopf & Nerkar, 2001), is consistent with research that has conceptualized exploitation as a process building intensively upon a firm's prior knowledge. Higher values on this measure indicate a greater focus on exploitative innovation in a given country-year.

We used two indicators to capture the extent to which an invention is the outcome of exploration. The first exploration measure is based on Trajtenberg, Jaffe & Henderson's (1997) patent 'originality' measure, which describes the range of technological fields that a patent draws upon. We used the International Patent Classification (IPC) system to identify the technological fields of a patent. For each invention, we created the list of all four-digit IPC classes characterizing the patent families cited in the invention's prior art, and we calculated the frequency of citations in each class. We computed our dependent variable on the basis of the bias-corrected Herfindahl index of concentration such that higher values indicate that the underlying search leading to a discovery has broader 'technological roots' (Hall, Jaffe, Trajtenberg, 2001). Referred to in the literature as 'capabilities-broadening' innovation or 'organizational breadth of search' (Argyres & Silverman, 2004), this measure is consistent with research that has conceptualized exploratory inventions as those resulting from a broad search process with uncertain results. Indeed, there is ample evidence that inventions drawing from more diverse sources have

higher probability of turning into breakthrough innovations (Fleming, Mingo & Chen, 2007; Arts & Veugelers, 2013; Kaplan & Vakili, 2012).

Our second measure of exploration, technology spanning, captures the extent to which a firm enters new or unfamiliar technology domains is also an indication of exploration (Ahuja & Lampert, 2001; McGrath & Nerkar, 2004; Phelps, 2010), thus operationalizing exploration relative to a firm's past behavior. Following prior research, we calculated the percentage of inventions in a given country year were classified in at least one technology class (a fourth-digit IPC class) in which the assignee had not patented over the five previous years.

Predictors

We collected annual country-level information on regulatory institutions from a variety of sources, including the UNESCO education statistics, the OECD Indicators of Employment Protection, the World Bank's World Development Indicators, the IMF International Finance Statistics, and Thomson Reuters Securities Data Company Platinum database. The variables described in the following paragraphs capture the institutions of interest for a longer time period than any alternative measures used by prior studies, and we believe they are also the most accurate. We performed various robustness checks using a series of alternative institutional variables.

Educational institutions. We used the *incidence of vocational training* to differentiate countries by the focus of their educational systems (Estevez-Abe, Iversen and Soskice, 2001). This measure was calculated as the sum of the proportions of secondary and tertiary students in the country that pursue vocational education, according to UNESCO Statistics. We collected four series of data to calculate our measure: total enrollment in public and private secondary programs; total enrollment in public and private vocational/technical programs; total enrollment in public and private, full and part-time, tertiary programs; and total enrollment in public and private, full- and part-time vocational tertiary programs. A higher incidence of vocational training characterizes countries with intense participation of industry and firms in the provision of education and a higher supply of employees with specific as opposed to general skills (Estevez-Abe et al., 2001; Iversen & Soskice, 2001). Likewise, lower values indicate that the educational system promotes a general occupational skills profile.

Labor institutions. A rich stream of research has measured labor institutions by the rigidity of labor and employment regulations (Bassanini & Ernst, 2002; Kiliçaslan & Taymaz, 2008; Capron & Guillén, 2009; Chacar, Newbury & Vissa, 2010). We use the OECD Indicators of Employment Protection dataset, which comprises 18 sub-indicators characterizing the strength of regulations for regular and temporary contracts in a country (Capron & Guillén, 2009). Higher levels of employment protection characterize countries with lower flexibility in the labor market. We constructed our variable, *flexibility of labor regulations*, by inverting the un-weighted average of these 18 sub-indicators, so higher values characterize countries with flexible labor regulations. In these countries, it is easier for firms to renew their workforce and to poach employees from their competition.

Market for corporate control. Following prior research, our measure of the *intensity of the market for corporate control* reflects the prevalence of attempted hostile takeovers in an economy (Rossi & Volpin, 2004; Capron & Guillén, 2009; Chacar et al., 2010). We calculated the ratio between hostile and total takeovers in a country in a given year, based on data from the Thomson Reuters SDC Platinum database. A higher ratio of hostile to total takeovers is an indication that managers face high competitive pressure.

Finance institutions. Based on work by Beck, Demirgüç-Kunt and Levine (Demirgüç-Kunt & Levine, 1999; Demirgüç-Kunt & Levine, 2009), our measure of the nature of country's *financial institutions* is the ratio of two indicators. The numerator, *stock market capitalization*, measures the size of the equity market (i.e. the value of listed shares) relative to the size of the economy in a given year. The denominator captures the incidence of *bank loans to private sector* and it is calculated by dividing the amount of private credit by deposit money bank by the country GDP in a given year. Underlying data comes from a dataset compiled by Beck et al. (2009) from the World Bank WDI, IMF IFS, and Standard and Poor's Emerging Market Database. Higher values indicate a more market-based financial system and lower values a more bank-based financial system. This variable has been widely used in the finance literature to gauge the importance of the capital markets relative to the banking system in an economy.

Control variables

We included several control variables. *Trade openness*, measured as the ratio of International Trade (Exports plus Imports) to GDP, accounts for the possibility that organizations located in more open

economies are exposed to more diverse sources of knowledge and thus might have more opportunities for exploration. The degree of a country's *technological diversification* controls for the possibility that more technologically diverse countries might draw from a larger pool of diverse knowledge and skills, which might create higher opportunities for exploration. Following Cantwell and Vertova (2004), we calculated this variable by assigning patent families to industries based on Schmoch's (2008) IPC-industry concordance scheme and calculating the technological diversification based on the 35 industries (technological areas) identified.

Three predictors control for differences in the composition of assignees whose patents we observed in a given country-year. Firm-level studies have argued that mature organizations tend to engage more actively in exploitation than exploration (Sorensen & Stuart, 2000). Lacking information on the age of the firms in our sample, we computed a closely related indicator of *innovation experience* as the number of years since we observed the first invention of an assignee in the entire PATSTAT database. We then took the average experience across all assignees whose inventions we observed in a given country-year. The *proportion of inventions assigned to firms filing a patent for the first time* controlled for the entry of new, typically more explorative, innovating firms (Lavie et al, 2010). We also controlled for the *average number of innovations* produced by firms in any given country-year.

GDP per capita captures differences in the level of economic development and its influence of development on firms' technological activities. The *technological size* of a country, measured by including the number of inventions filed in a country-year, captures the extent to which countries are more or less technologically active, as opposed to being more or less wealthy and economically developed (Cantwell and Vertova, 2004). We also included year dummy variables to control for period effects such as common shocks in the macroeconomic conditions or technological opportunities.

Model Specification and Estimation Method

The main sample consisted of a time-series cross-sectional dataset of pooled yearly observations in 22 countries over 24 years. Because the search processes leading to invention precede the date patents are applied for, we used a one-year lag in the values of the institutional variables and other country-specific

predictors. We controlled for the contemporaneous effects of the technological attributes of the patents and patenting firms.

We applied panel-corrected standard errors (Beck & Katz, 1995) to address contemporaneous correlation of error terms across countries in a time period and variation in the scale of the error term across countries (heteroskedasticity). Since a Lagrange Multiplier test (Wooldridge, 2010) indicated autocorrelation of errors within countries across time, we allowed the errors to follow a first-order autoregressive (AR1) process.

The pooled time-series model combines the within-and-between country effects into a single effect. As we show later in this paper, the two effects have substantively different implications for understanding the institutional effects on exploration-exploitation. Therefore, we supplement our analysis with a modeling approach that enabled us to disentangle the longitudinal and cross-country institutional effects. This estimation technique, although long documented in the literature (Mundlak, 1978), has only recently been widely discussed as the most appropriate way of estimating both within and between-cluster effects in the same equation (Bartels, 2008; Leyland, 2010; Bell & Jones, 2013). This specification includes (a) yearly deviations from the country-specific average score of each predictor as an indication of within-country effects and (b) country-specific means for each predictor which show the between-country effects of the predictors.

This technique has two advantages over fixed- and random-effects approaches. First, it produces statistically efficient coefficients for slowly changing institutional predictors, whereas fixed effects perform very poorly with such data (Wooldridge, 2010). Second, by including the within-country transformations of the predictors, the independent variables become uncorrelated with the between-cluster random effects, removing the main source of bias in the random-effects approach (Bartels, 2008).

RESULTS

Table 1 reports descriptive statistics and correlations. The mean and the range of dependent variables are similar to values reported by prior studies at the firm level. Variance inflation factors (VIF) indicated low collinearity, with a mean VIF of 1.80 and maximum of 3.49.

-----Insert Table 1 here-----

We begin by discussing the results of the pooled regressions displayed in Table 2. Models 1 and 2 show the results for exploitation and Models 3 through 6 those for our two measures of exploration. Our first two hypotheses examined institutions influencing intra-organizational socialization. As predicted by our first hypothesis, educational systems where vocational training is widespread and widely institutionalized encourage exploitation, but lead to lower levels of exploration as measured by technology spanning. Contrary to hypotheses 2a, we find no evidence that labor regulations influence exploitation, which may be explained by micro-level theories suggesting that once organizational routines for exploitation are put in place, they are less likely to be affected by personnel turnover (Levinthal & March, 1993). However, higher flexibility in hiring, firing, and employee mobility is essential for exploration, and firms operating in countries with more flexible labor regulations tend to produce more explorative innovations, as measured by originality.

Institutions shaping inter-organizational competition appear to affect exploration, but not exploitation. Thus, H3a and H4a are not supported. Consistent with hypotheses 3b and 4b, a more active market for corporate control leads to higher levels of technology spanning and market-based financial institutions have a positive impact on exploration, as measured by originality. Among controls, as expected, trade openness and technological diversification also encourage exploration.

-----Insert Table 2 here-----

The general picture that emerges from the pooled analysis is that exploitation processes are affected only by the profile of skills supported by the national education systems, while exploration is heavily influenced by all macro-level factors identified in our theoretical discussion: education, labor, corporate control, and financial institutions. However, pooling conflates the effect of institutional changes within a country over time and of enduring differences in institutions between countries. To account for these distinctive effects, we reran the analysis separating the within and between effects (Bartels, 2008; Bell & Jones, 2013). Results are shown in Table 3.

-----Insert Table 3 here-----

We begin by considering the differences between our original pooled analysis and the current analysis. Because within and between effects are not conflated, we find stronger evidence for the effect of the

incidence of vocational education on exploration (H1b), with cross-country differences in educational systems discouraging both originality (model 10) and technology spanning (model 12). There is also stronger evidence for the impact of labor market flexibility (H2b) on exploration, with both within and between country effects encouraging originality (model 10) and within country effects encouraging technology spanning. We also find stronger evidence for the effects of institutions shaping the competitive ecology. Unlike the original analysis, both a more active market for corporate control (H3a) and a more market oriented financial structure (H4a) reduce exploitation (model 8, between effects). Evidence for the effects of these institutions on exploration is also more consistent, with both originality and technology spanning increasing with a more active corporate control market (H3b) and a more market oriented financial structure (H4b, models 10 and 12, within effects).

The most interesting insights, however, come from comparing the impact of within- and between-country effects on levels of exploitation and exploration. The level of effort that firms put on exploitation depends heavily on the ecology of competition in the domestic market, but one can only observe this effect by isolating the enduring differences in inter-organizational competition across countries (between effects, model 8). Our conclusions are unambiguous in this regard: there is a stronger exploitation orientation in countries where the external environment does not pressure firms to compete for primacy. The average score of exploitative innovation is higher in countries with fewer hostile takeovers and with bank-based rather than a market-based financial system. Furthermore, it is higher in countries where the educational system promotes vocational training education.

In any given country, the intensity of exploitation decreases once the educational system starts to place more emphasis on general education, although the effect is small relative to that of between country differences. Comparing the within and between coefficients in model 8 shows that a given difference in the incidence of vocational education has over 4.5 times more effect as an equivalent change within a countries educational system (0.055/0.012). Overall, exploitation behavior is less affected by changes in the national institutions than by differences between countries. We believe this result occurs because exploitation orientation is deeply rooted in inertial tendencies, and thus, it is less likely to respond immediately to short run changes in the external environment.

A different pattern emerged when we looked at the institutional determinants of exploration between and within countries. Firms alter their exploration strategies more thoroughly in response to shifts in the institutions affecting competition within a country. When labor market become more flexible, firms tend to engage in more exploration. This could be because it is easier to maintain a more diversified knowledge pool through hiring and firing, but also because firms might become more risk-taking once downsizing and reshuffling can be done easier if an exploratory projects fails (Bassanini & Ernst, 2002). Furthermore, higher competitive pressures also change firms' incentives towards more risk taking. In short, firms tend to pursue more exploratory innovations as labor markets become more flexible, markets for corporate control more competitive, and financial systems more market-oriented, all of which are broad tendencies in our sample. Educational systems are an exception to this pattern: inventions generated in countries that provide high levels of training in firm or industry-specific competencies are systematically less explorative. Within country changes in the educational system do not increase exploration immediately, likely reflecting the time required for changes to infiltrate the work-force.

Robustness checks

We performed extensive robustness checks. First, we tested our models using alternative measures of the institutional covariates. Beginning in 1995, when the relevant survey items became available, we used items from the IMD World Competitiveness Report to measure labor institutions flexibility (“Labor regulations (hiring/firing practices, minimum wages, etc.) do not hinder business activities”, (Chacar *et al.*, 2010)) and the intensity of competition (“Competition legislation is efficient in preventing unfair competition” and “The value system in your society supports competitiveness”). Results remained nearly identical for exploitation and breadth of search but survey measures were not significant for technology spanning. Lastly, in place of the aggregate index of financial structure we looked the absolute size of the equity market and the banking system. The analysis using these measures leads to the same substantive conclusions as before, with the size of the banking system having a stronger impact than the stock market predictor.

Second, we ran all analyses using alternative model specifications. Because the dependent variables are fractional responses bounded between 0 and 1, we re-estimated our models using a

generalized linear model (GLM) approach in which we specified a probit link function and computed robust standard errors (Papke & Wooldridge, 1996), finding results consistent with Table 3.

Third, we included dummy variables for observations from outliers including Portugal and Greece, the two countries with the lowest numbers of inventions in our sample, and the U.S., the country with the highest number of inventions. The variables were not significant and did not change the effect of other predictors.

Lastly, because data from the early 1980s used to generate the *technology spanning* variable might not have been as accurate as later data, we ran our analyses restricting the time period to 1990-2008. Results remained unchanged.

DISCUSSION AND CONCLUSION

This study responds to recent calls for a better understanding of the antecedents of exploration and exploitation. We built our approach on the premise that the allocation of resources within an organization toward a particular innovation path is an adaptation response to the social context of learning. We integrated institutional, learning and innovation literatures and examined whether and to what extent the direction of firms' innovation search toward exploration or exploitation is influenced by the institutional environment. We examined aggregate, country-level patterns of exploration-exploitation to understand whether firms exposed to similar/different institutional environments respond consistently in their search behavior.

Although exploration-exploitation are quintessentially organizational processes, we found considerable support for our argument that they are influenced by macro-institutional factors. Cross-country differences in the institutions influencing intra-organizational processes (particularly education) are associated with systematic cross-country differences in both exploration and exploitation. Institutions regulating the competitive environment also have an impact on exploration-exploitation, but our conclusions here are more nuanced. The degree of exploitation varies between countries according to the long-term differences in the intensity of competitive pressure that markets for corporate control and financial systems put on firms. However, firms do not exploit less if country-level institutions start to put more competitive pressure on firms. It is the long term difference in levels that matters.

Firms' incentives to explore are sensitive to changes in the nature of competitive pressure in the countries in which they operate. Increased pressure to perform well relative to competitors changes the behavior towards risk taking and exploration within a country. Interestingly, we do not find evidence that systematic differences across countries in the nature of competition translate into systematic differences across countries in the level of exploration. It may be that, given the risks inherent in pursuing exploration, firms within any stable competitive ecology gravitate over time towards a competitive equilibrium that allows them to moderate their exploratory activity. Changes in that competitive ecology, such as an increase in competitive pressure, disrupt the equilibrium in the short-run, leading to increased exploration.

This study makes four primary contributions. First, it contributes to the innovation search literature. While the majority of past studies have assumed that exploitation innovation is facilitated by firms' tendencies towards local search (e.g. Rosenkopf & Nerkar, 2001; Phelps, 2010), and thus, that it is less affected by the external environment, we show that institutions have an enduring effect on exploitation. However, firms do not easily alter their local search behavior as a response to short-term institutional change. The differences in exploitation behavior occur across firms operating in different countries, and stem from long-run differences in national institutions. Interestingly, firms' incentives to explore can be influenced in the short-run by changes in the national institutions, in particular, by regulations that transform the nature of competition in an economy or the labor market.

Second, this study contributes to recent work that seeks to untangle the underlying institutional and structural characteristics of countries that account for heterogeneity in organizational processes and firm performance levels (e.g. Schneper & Guillen, 2004; Henisz & Swaminathan, 2008; Chacar et al., 2010; McGahan & Victor, 2010; Crossland & Hambrick, 2011). More specifically, it is the first study of which we are aware that responds to a recent call by Lavie et al. (2010:142) to examine "cross-national differences in organizations' tendency to explore or exploit". This study shows that macro-level influences on exploration-exploitation behavior stem from two sources of influence. One is the effect of institutions that regulate the influx of knowledge diversity and turnover in organizations. The other is the effect of institutions that shape the performance aspiration levels in an economy. Although these

institutions aim primarily at objectives other than innovation, they influence firms' innovation search effort by affecting the resources made available to firms, the 'costs' associated with search-specific processes, and the rewards associated with search-specific outcomes.

Our third contribution spans theoretical research and managerial practice regarding determinants of the optimal location of innovative activities. Because institutional factors are difficult to change through short-term managerial actions, understanding the institutional antecedents of exploration-exploitation has important consequences for managerial practice. In particular, our findings imply that the optimal location of R&D activities is highly contingent on the desired goal of those activities—exploitation and extension of the firm's existing knowledge or generation and exploration of new knowledge. The presence of "skilled labor" and "capital" is not enough; the specificity of the workforce's skills and the sources of capital are critical to the success of R&D. Characteristics sometimes viewed as antithetical to "innovation", such as relatively inflexible labor regulations may rather be antithetical to *exploratory* R&D, but neutral or even favorable to *exploitive* R&D, which can play a critical role in a firm's performance.

Our final contribution links theory and empirical advances. Our conclusions are based on a novel and comprehensive data set of innovations produced by firms in 22 countries during a period of 24 years and filed in the three most important patent offices in the world. Enabled by a modeling approach not previously used in similar research, the cross-temporal and cross-country variation in institutions has provided an ideal setting for investigating the degree to which innovation search behavior is an adaptation response to the social context of learning. Although organizations and institutions co-evolve (Cantwell, Dunning, Lundan, 2010), we have demonstrated that co-evolution can be limited and uneven. The effect of institutional changes within a country over time and of enduring differences in institutions between countries differs according to the nature of the change (intra-organizational socialization or inter-organizational competition) and the behavior being observed (exploitation versus exploration). This modeling approach is generalizable to many of the other cross-temporal/cross-country changes that permeate international business scholarship.

An empirical caveat is our use of patent-based measures, which are imperfect reflections of innovation. In an important advance, the OECD HAN database allowed us to construct a cross-national panel of patent family data reflecting a thorough harmonization of assignee names. But, if HAN failed to properly harmonize alternative names for some assignees, we may have underestimated the degree of self-citation and, thus, exploitation. However, any potential bias would be captured in the intercept and not in the response to our covariates.

Our analysis suggests a number of additional implications and avenues for future research, of which we highlight four. First, firms can search across multiple domains spanning geographic, organizational, and technological space (Rosenkopf & Nerkar, 2001; Phelps, 2010). We focused on technological and organizational space, but the geographic dimension is of equal importance. In particular, our current findings suggest the need to examine whether multinational enterprises engage in ‘institutional arbitrage’ by locating their exploratory activities in those economies that offer the most favorable institutional environment (Jackson & Deeg, 2008).

Second, the question of whether and how institutions affect exploration and exploitation lends itself to examining dependent variables defined at many levels of analysis, including organizations, industries, and countries. One could also test for interactions between firm and country level explanations. This paper provides a necessary step toward a multi-level analysis by establishing the existence of institutional effects on exploration and exploitation across countries and over a long time period.

Third, it would be interesting to observe the process through which these institutional factors act. In doing so, extending the scope of the analysis to other institutions might also be useful, since some institutions may be substitutes and others complements.

Lastly, we hope this paper will stimulate further discussion of the extent to which globalization and new information technologies are leading to the convergence of national innovation systems. Even if national innovative capacities are converging (Furman, Porter & Stern, 2002), questions can be raised on whether innovation paths (explore-exploit) are also converging and, if so, at what rate.

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Table 1: Descriptive Statistics and Correlation Matrix

Variable	Mean	S. D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Exploitation	0.079	0.028	0.000	0.163	1.000												
2. Originality	0.689	0.049	0.450	0.823	0.238	1.000											
3. Technological Spanning	0.686	0.071	0.359	0.900	-0.429	-0.182	1.000										
4. Incidence of vocational education	0.360	0.181	0.000	0.959	0.309	-0.026	-0.277	1.000									
5. Flexibility of labor regulation	2.308	1.023	0.210	4.190	0.165	0.509	0.226	-0.161	1.000								
6. Market for corporate control	0.006	0.048	0.000	1.000	-0.130	-0.020	0.161	-0.012	-0.014	1.000							
7. Financial structure	-0.526	0.782	-5.054	1.566	0.109	0.488	0.033	0.065	0.455	-0.051	1.000						
8. Trade openness	66.950	31.760	15.920	182.880	0.066	0.215	-0.306	0.427	-0.039	-0.047	0.076	1.000					
9. Technological diversification	1.238	0.360	0.541	2.995	0.186	0.226	0.013	-0.260	0.215	0.028	0.043	-0.280	1.000				
10. Innovation experience	15.374	5.780	2.000	30.975	0.716	0.345	-0.432	0.162	0.116	-0.128	0.266	0.131	0.373	1.000			
11. Proportion of first-time patentees	0.248	0.078	0.000	0.563	-0.292	-0.157	0.561	-0.027	0.293	0.100	0.108	-0.148	-0.165	-0.418	1.000		
12. Number of innovations per firm	1.942	1.495	0.253	10.510	0.563	-0.013	0.063	0.013	0.136	-0.040	0.134	-0.233	0.167	0.559	-0.029	1.000	
13. GDP per capita	9.913	0.415	8.428	10.643	0.557	0.420	-0.028	0.272	0.491	-0.001	0.374	0.074	0.151	0.354	0.045	0.336	1.000
14. Technological size	8.029	16.912	0.003	95.027	0.384	0.380	0.084	-0.181	0.378	-0.035	0.283	-0.210	0.530	0.538	-0.070	0.586	0.404

Table 2: Pooled OLS. Panel Corrected Standard Errors. AR(1)

	Exploitation (Self-citations)		Exploration (Originality)		Exploration (Technological Spanning)		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	
Trade openness	-0.000 (0.000)	-0.000 (0.000)	0.000** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000** (0.000)	
Technological diversification	-0.005 (0.006)	-0.004 (0.006)	0.015 (0.012)	0.017** (0.007)	0.047*** (0.018)	0.048*** (0.012)	
Innovation experience	0.002*** (0.000)	0.002*** (0.000)	-0.002* (0.001)	-0.002*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)	
Proportion of first-time patentees	-0.054*** (0.021)	-0.058*** (0.020)	-0.173*** (0.049)	-0.191*** (0.029)	0.339*** (0.068)	0.333*** (0.046)	
Number of innovations per firm	0.004*** (0.001)	0.004*** (0.001)	-0.009*** (0.002)	-0.007*** (0.002)	0.010*** (0.003)	0.011*** (0.003)	
GDP per capita	0.027*** (0.005)	0.024*** (0.005)	0.031** (0.012)	0.009 (0.007)	0.007 (0.012)	0.005 (0.008)	
Technological size	-0.000** (0.000)	-0.000* (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	
Constant	-0.200*** (0.053)	-0.177*** (0.056)	0.455*** (0.129)	0.647*** (0.077)	0.470*** (0.134)	0.492*** (0.080)	
Incidence of vocational education	H1	0.023*** (0.007)		-0.013 (0.012)		-0.034** (0.016)	
Flexibility of labor regulation	H2	0.002 (0.002)		0.015*** (0.002)		0.002 (0.003)	
Market for corporate control	H3	-0.020 (0.015)		0.033 (0.022)		0.066* (0.036)	
Financial structure	H4	-0.001 (0.003)		0.013*** (0.003)		0.006 (0.004)	
R ²		0.43	0.44	0.82	0.84	0.78	0.79
N		506	496	506	496	506	496

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

Standard errors between parentheses. Year dummies are included in all models.

Table 3: Within-Between Effects

	Exploitation (Self-citations)				Exploration (Originality)				Exploration (Technological Spanning)			
	Model 7		Model 8		Model 9		Model 10		Model 11		Model 12	
	Within	Between	Within	Between	Within	Between	Within	Between	Within	Between	Within	Between
Trade openness	-0.000*** (0.000)	0.000 (0.000)	-0.000*** (0.000)	-0.000 (0.000)	0.000** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Technological diversification	-0.014*** (0.002)	0.007 (0.016)	-0.015*** (0.002)	0.004 (0.012)	0.007 (0.005)	0.014 (0.037)	0.009** (0.005)	-0.009 (0.028)	0.051*** (0.007)	0.003 (0.036)	0.051*** (0.007)	-0.009 (0.034)
Innovation experience	0.001*** (0.000)	0.002** (0.001)	0.001*** (0.000)	0.002** (0.001)	-0.001** (0.000)	0.002 (0.002)	-0.001*** (0.000)	0.003 (0.002)	-0.004*** (0.001)	-0.005** (0.002)	-0.004*** (0.001)	-0.004 (0.003)
Proportion of first-time patentees	-0.026** (0.012)	-0.039 (0.046)	-0.041*** (0.013)	-0.045 (0.043)	-0.084*** (0.023)	0.043 (0.109)	-0.068*** (0.025)	-0.086 (0.098)	0.384*** (0.036)	0.413*** (0.106)	0.362*** (0.039)	0.400*** (0.123)
Number of innovations per firm	0.004*** (0.001)	0.006** (0.003)	0.005*** (0.001)	0.003 (0.002)	-0.005** (0.003)	-0.015** (0.007)	-0.006** (0.003)	-0.012** (0.005)	-0.006 (0.004)	0.010 (0.007)	-0.008* (0.004)	0.011* (0.007)
GDP per capita	0.039*** (0.007)	0.026*** (0.006)	0.048*** (0.009)	0.024*** (0.006)	0.016 (0.014)	0.017 (0.015)	0.017 (0.016)	0.008 (0.014)	-0.034 (0.022)	0.005 (0.015)	0.006 (0.025)	0.013 (0.018)
Technological size	-0.001*** (0.000)	-0.000 (0.000)	-0.001*** (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.001** (0.001)	-0.000 (0.000)	0.001 (0.000)	0.001** (0.000)	0.001** (0.001)	0.001** (0.000)	0.001 (0.001)
Constant	-0.218*** (0.065)		-0.205*** (0.062)		0.498*** (0.153)		0.635*** (0.143)		0.513*** (0.149)		0.469*** (0.179)	
Incidence of vocational education	H1		0.012** (0.005)	0.055*** (0.018)			-0.003 (0.010)	-0.083** (0.042)			-0.019 (0.015)	-0.092* (0.052)
Flexibility of labor regulation	H2		0.003 (0.002)	0.003 (0.003)			0.010** (0.004)	0.013** (0.006)			0.015*** (0.006)	-0.003 (0.007)
Market for corporate control	H3		-0.004 (0.011)	-0.522*** (0.186)			0.037* (0.021)	0.429 (0.429)			0.075** (0.032)	0.017 (0.534)
Financial structure	H4		-0.002 (0.001)	-0.007* (0.004)			0.006*** (0.002)	0.016 (0.010)			0.002 (0.003)	0.016 (0.012)
Var (Country-year level error)		0.010		0.007		0.024		0.016		0.022		0.020
Var(Country level error)		0.011		0.011		0.021		0.021		0.033		0.032
Country-level error/Total error		0.444		0.284		0.554		0.375		0.312		0.277
N		506		496		506		496		506		496

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

Standard errors between parentheses. Year dummies are included in all models.