Corporate Governance: An International Review, 2013, ••(••): ••–••

Innovation and Family Ownership: Empirical Evidence from India

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ABSTRACT

Manuscript Type: Empirical
Research Question/Issue: This study examines the direct effect of family ownership on innovation in emerging markets by using data from Indian family-controlled publicly listed firms as its sample. In particular, we study (1) the direct effects of family ownership on innovation and (2) the influences of business group affiliation on these family firms.
Research Findings/Insights: Using an unbalanced panel of 395 Bombay Stock Exchange (BSE) listed Indian firms during the years 2001 and 2008, we found that the impact of family ownership on innovation productivity is positive (after controlling for possible endogeneity). We further emphasized the business group affiliation of family firms and distinguished between the innovation activities of group-affiliated and stand-alone family firms. We found that affiliating with top 50 business groups increases the innovation activities of these family firms.
Theoretical/Academic Implications: Theoretically, we complement agency theory by incorporating both the institutional perspective and the external resourcing perspective to provide a more robust framework for examining the impact of family ownership on innovation in emerging markets. Methodologically, we adopted a more rigorous econometrics method by providing a panel analysis that used a system GMM estimator and addressed the endogeneity issue thoroughly, which represented a significant improvement over the shortcomings of the methodologies found in the existing literature.
Practitioner/Policy Implications: Our findings suggest that the Indian government should provide support for affiliating family firms with business groups while improving policies on information disclosures; it should also establish a proper corporate governance mechanism for private and public family business. The findings further suggest that a corporate governance code should encourage family firms to have an independent professional CEO.

Keywords: Corporate Governance, Patent, Innovation Productivity, Family Firms, Indian Business Group

INTRODUCTION

There is a substantial body of literature that examines the characteristics and performance of firms with respect to innovation. However, there is scant evidence about a direct relationship between family ownership and innovation (Craig & Moores, 2006). This issue is more important for emerging markets than for markets in developed economies because globalization of emerging markets brings both opportunities and pressure for the domestic family-owned firms to innovate and alleviate competition for long-term survival (Aghion, Burgess, Redding, & Zilibotti, 2005). Furthermore, Choi, Park, and Hong (2012) argue that prior agency theory literature that addresses the role of ownership structure on innovation from the agency perspective does not capture the relationship in emerging markets.

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The literature on corporate governance has shown that the dynamics of ownership structure can influence technological innovation (e.g., Lee & O'Neill, 2003). Family ownership is the dominant form of business around the world and there is ample literature that studies family ownership issues (e.g., Villalonga & Amit, 2006). However, a salient aspect of that literature is the absence of studies on the effects of family ownership on firm innovation. The existing literature on this topic is rare and inconclusive from both developing (Chen & Hsu, 2009; Kim, Kim, & Lee, 2008) and developed countries (Block, 2012; Sirmon, Arregle, Hitt, & Webb, 2008). In addition, Le Breton-Miller, Miller, and Lester (2011) observe contradictory evidence of investment for innovation by family firms. For instance, one stream of the literature shows that family owners follow strategies of conservatism by maintaining regular income and restricting investment in innovation to avoid risk, which ensures the security of their wealth (Claessens, Simeon, Fan, & Lang, 2002). Another stream of the literature argues that family owners and managers sacrifice

doi:10.1111/corg.12034

their personal interests to invest in innovation to make their firm healthy and durable and to enhance stakeholders' value (James, 1999).

Studies on blockholders of publicly traded firms suggest that the contribution of large shareholders to their firms often depends on their identity in particular institutional environments (Claessens, Djankov, & Lang, 2000). In emerging markets, it is argued that weak investor protection, poor judicial systems, inefficient intellectual property protection, corrupt legal systems, under-developed capital markets and other institutional weaknesses make family ownership more concentrated, which inevitably affects firm performance (Khanna & Palepu, 2000a). However, there have been only limited studies that directly examine the impact of family ownership on innovation, although it has been increasingly recognized that innovation can improve firm performance and firm value (Blundell, Griffith, & Van Reenen, 1999; Cho & Pucik, 2005). Furthermore, the limited studies on family ownership and innovation were undertaken either from an external resourcing perspective (e.g., Sirmon & Hitt, 2003) or from an agency perspective (Choi, Lee, & Williams, 2011; Morck & Yeung, 2003). There is no noteworthy study that attempts to reconcile agency theory and institutional theory to investigate the impact of family ownership on firm value (Liu, Yang, & Zhang, 2012; Peng & Jiang, 2010), which opens an avenue to explore this important yet undeveloped issue. This issue is relevant and important to emerging markets because these markets have underdeveloped institutions (or no institutions); this hinders the functionality of markets, such as in India, in which large family business groups are some of the most important drivers of innovation and are responsible for large parts of the country's economic growth (Chakrabarti, Megginson, & Yadav, 2008; Piramal, 1996).

Based on these gaps in the literature, this study aims to complement the agency theory by incorporating both an institutional perspective and an external resourcing perspective to provide a better framework for examining the impact of family ownership on innovation in emerging markets, by using Indian family-controlled publicly listed firms as its sample. In particular, we study (1) the direct effect of family ownership on innovation and (2) the influence of business group affiliation of these family firms on innovation. In this study, our focus is on publicly traded family-controlled businesses, in which non-family individuals or institutions hold some of the equity. Therefore, we use a unique data set of 395 Indian firms listed on the Bombay Stock Exchange between the years 2001 and 2008 as our sample.

Methodologically, we adopt a panel data set of patenting information on these firms around the world that no existing literature in this field has analyzed. This data set reveals intra-firm variations in innovation. Controlling for time-varying decisions of the firms to remain family owned and for other sources of endogeneity, we apply a well-developed system-GMM estimator. After addressing reverse causality between family ownership and innovation, our results show that Indian family ownership increases innovation output and improves firms' innovation capacity. We also find that affiliating with top business groups contributes significantly to improving firms' innovation.

We focus our study on Indian firms because India typifies emerging markets that feature institutional underdevelopment (absence of or underdeveloped institutions that prevent the functioning of intermediate markets) and is a good example of a market with dominant family ownership. Approximately 70 percent of the Indian firms are family-controlled and they are the driving forces of innovation in India because of the absence of other types of concentrated ownership, such as state-owned firms (Chakrabarti et al., 2008; Piramal, 1996). These family firms usually engage with the government opportunistically; thus they are not always closely associated with politicians (such as *Chaebol* in South Korea). Indian family firms are free from rigging markets (such as in Mexico and Israel) and are also under market pressure imposed by new entrant competition. These features make Indian family firms unique and distinguish them from comparable firms in other emerging markets.

Moreover, Indian family firms have another distinct feature. Most are affiliated with large business groups for external resourcing (for further discussion, see Khanna & Palepu, 2000b:870). A number of studies have recognized that business groups in emerging economies can mitigate the distortion of the labor and capital markets and that group-affiliated firms can share a group-wide reputation that might offer access to external credit (Claessens et al., 2000; Khanna & Palepu, 2000b). Because the groups create their virtual (internal) capital markets (Manos, Murinde, & Green, 2007), the group-affiliated family firms can pool and re-allocate funds in accordance with investment opportunities (Bertrand, Mehta, & Mullainathan, 2002). These features of business groups in India make group-affiliated family firms an important business arrangement to compensate for institutional underdevelopment (also used as institutional voids in many studies) and an inefficient capital market. Therefore, we argue that the affiliation of Indian family firms with business groups can positively influence the relationship between family ownership and innovation, which makes the impact of family ownership on innovation even more unique in India compared to developed and other developing economies.

The remainder of this paper is organized as follows. The next section presents the literature review and our hypotheses. We then introduce the dataset and describe the variable design and econometric models. This is followed by an explanation of the empirical results, including robustness tests. The final section concludes the study with implications.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Family Ownership and Innovation

Innovation is the process of developing new technological knowledge and putting that knowledge to productive use. Cohen and Klepper (1996) differentiate innovation as process and product innovation – process innovation reduces production costs and product innovation increases the price that consumers are willing to pay. Both types of innovation are associated with the following risk factors: (1) The probability of the failure of R&D investment is higher than that of conventional investments; (2) new technologies tend to be opaque (Rajan & Zingales, 2001), which means that innovation is often less understood by market participants; and (3)

the expected return on new technology depends on the firm's lead-time advantage, which means that the possibility of imitation by competitors may decrease the profitability of successful innovation projects (Helpman, 1993). Therefore, successful innovation requires sufficient innovation investment (such as R&D, marketing, programs to educate consumers about new technologies and products), and investment in external resourcing (such as attracting and retaining entrepreneurs and talented scientists). Therefore, well-developed financial systems are desirable for innovation (Hyytinen & Toivanen, 2005).

The ownership structure of a firm is an important determinant of its innovation activities (Lee & O'Neill, 2003) because ownership concentration may efficiently resolve agency problems or at least so it has been argued (Shleifer & Vishny, 1997). Large shareholders that care about the stability of the firm focus on long-term investment in new technology development even though it may mean temporary fluctuations in stock prices (Choi et al., 2012).

Family control is the dominant form of business around the world, but particularly in emerging markets; it is typically unchallenged by other equity holders (La Porta, Lopez-de-Silanes, & Shleifer, 1999). In many instances, family-owned businesses take the form of a small family business, whereas it is a large business employing hundreds, or even thousands of staff in other cases. For instance, studies document that one-third of the S&P 500 (Anderson & Reeb, 2003) and Fortune 500 (Shleifer & Vishny, 1986) firms are family firms. In emerging markets, the large family-controlled business structure is far more common (Manikutty, 2000), and this has particularly significant effect on innovation because these large family firms possess the advantages in R&D investment and economies of scale that are required for successful innovation. India is a good example of this type of emerging market because approximately 70 percent of Indian firms are family-controlled and large family-controlled business is a driving force of innovation in India because of the absence of any other type of concentrated ownership (e.g., Piramal, 1996).

The Extant Literature on Family Ownership and Innovation

In family-controlled businesses, it has been argued that the most severe agency problems result from the conflict of interest between majority and minority shareholders (La Porta et al., 1999). Therefore, the influence of family ownership on firm innovation originates from how well the two parties work together to reduce the agency problem and optimize resource allocation (Belloc, 2012). On the one hand, the advantage of family-controlled business is that concentrated family ownership means a high level of family involvement in the firm, particularly when the founders of the family serve as CEO or are on the board of directors. They have a strong attachment to and interest in their firms. Therefore, the incentive alignment argument is overwhelming and it reduces the agency problem between family (majority shareholder) and other equity holders of the firm (minority shareholders). More recently, there have been studies that extend agency theory to explain the impact of family ownership and innovation by incorporating stewardship theory. These studies show that the family normally holds its stakes for a long time and targets greater benefits, such as the firm's growth, technological innovation and long-term firm survival (Anderson & Reeb, 2003; Le Breton-Miller et al., 2011). Moreover, family ownership tends to invest in R&D and technological innovation rather than opting for the traditional approach of sales maximization for short-term profitability. Therefore, family ownership should have a positive effect on a firm's innovation activities.

On the other hand, however, it has also been argued that family owners tend to expropriate corporate wealth because they hold a significantly great percentage of the outstanding stock and usually dominate the board of directors (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 2000). When this behavior arises, it creates a significant agency problem between majority and minority shareholders. When insider family owners expropriate outside investors by diverting corporate resources for their personal interests, it is difficult to raise financing for technological projects and to allocate capital to invest in innovation (Morck, Wolfenzon, & Yeung, 2005). Therefore, the impact of family ownership on innovation might be negative.

Thus far, there are only limited empirical studies to test the above theoretical arguments, and they have focused mostly on R&D activities in family-controlled business, leaving the direct examination of the role of family ownership on innovation unexamined. Moreover, because the empirical evidence comes from both developed and emerging markets, the results are inconclusive.

Studies in developed economies note that founding families – because they are aware of the learning curve of their firms – generally have insider knowledge of R&D activities (Anderson & Reeb, 2003), which enhances innovation capabilities. In addition, by holding large equity ownership portions of these firms, founding families tend to want to invest more in R&D (Block, 2012). However, using survey data collected by Banque de France, Sirmon et al. (2008) show that French family firms maintain higher investment in R&D than non-family firms, which leads to higher innovation performance, but the innovation performance decreases as the level of ownership held by families increases.

In Korea, another emerging market, Kim et al. (2008) show that family members are more willing to invest in long-term projects, such as R&D, for their firms than other shareholders. Ayyagari, Demirgüç-Kunt, and Maksimovic (2011) study 19,000 firms across 47 developing countries and find that controlling families improve a firm's innovation activities. However, investigating data from Taiwanese family firms, Chen and Hsu (2009) argue that family members may abuse their power and misuse the funds, which leads to decreasing R&D intensity.

Gaps in the Literature

The prior literature on agency theory indicates that agency theory – even when reconciled with stewardship theory – cannot provide a convincing explanation for the role of family ownership on innovation, because the agency framework has yet to fully address the influence of the institutional settings of emerging markets. La Porta et al. (1999) argue that the agency problem between majority and minor-

ity shareholders and the effectiveness of the agency framework to reduce the agency problem is largely influenced by the institutional environment, such as poor protection of minority shareholders. In addition, in emerging markets, the use of pyramidal groups to separate the cash flow rights from the voting rights of majority family owners leads to the entrenchment of the dominant family. One of the dominating mechanisms of this type of expropriation of minority shareholders in emerging markets is transferring (tunneling) a significant proportion of wealth by the family owners from firms in which they have large control rights to firms in which they have both large cash flow and control rights (Johnson, La Porta, Lopez-de-Silanes, & Shleifer, 2000; Morck & Yeung, 2003). This tunneling of assets in the pyramidal structures of family firms leads to gain by the family at the expense of other stakeholders. Recent studies have documented such problems in family business groups in Western European and East Asian markets (Claessens et al., 2000; Faccio & Lang, 2002). Because of persistent tunneling, the agency conflict may decrease revenues and affect the innovation activities of family firms. However, the literature has not fully addressed the complex relationship between family ownership and its influence on innovation, particularly in emerging economies. Therefore, the first gap we have identified in the existing literature is that there is a lack of evidence to help reconcile certain conflicting results from agency theory and the institutional perspective to explain the role of family ownership on innovation.

The second gap we have identified in the literature is that there are limited empirical studies that have examined family ownership and innovation from an external resourcing perspective in emerging markets. With respect to the external resourcing perspective, this issue is particularly important in India because a large number of Indian family firms are affiliated with business groups that are the primary channel of providing and accessing resources (Piramal, 1996). As we mentioned earlier, innovation activities significantly depend on external resourcing (technology transfers, attracting and retaining talented scientists, foreign direct investment, etc.), which is also influenced by the institutional framework of any specific country. Therefore, this raises the question of how Indian family firms can enhance innovation through external resourcing with weak institutions.

Hypothesis Development

The type (and degree) of agency problems in listed firms is largely affected by ownership structure and institutional environment (La Porta et al., 2000). We will investigate how the ownership structure of listed family business shapes agency problems and how the relationship between family ownership and innovation may be affected by variation in the institutional framework.

The literature argues that, in developed economies such as the United States or the United Kingdom, better legal protection for shareholders (particularly for minority and outside shareholders) encourages founding families and the family members to dilute their equity (Peng & Jiang, 2010). The concentration of ownership in listed family business is much less in developed countries than in emerging markets (Khanna & Palepu, 2005). The ownership structure of listed family firms in developed markets is dispersed compared to that in emerging markets; thus, in developed markets, the agency problem between majority and minority shareholders is not of major concern (La Porta et al., 2000), and the dominant agency problem is conflicts of interests between owners and managers (Morck & Yeung, 2003).

A special feature of family business in India is that large firms belong to family business groups in affiliation with business groups (Chakrabarti et al., 2008). In business groups, the family firms control other firms; following a pyramid structure, each firm again controls many other firms (Morck & Yeung, 2003). Although public shareholders provide capital at different stages of the pyramid structure, they do not become the majority shareholder in any family firm affiliated with the group, and their role in providing capital and corporate governance related activities is insignificant (Morck & Yeung, 2003).

In addition to this pyramid ownership structure and similar to other emerging economies, India is also characterized by the absence of sufficient judicial and regulatory institutions, which leads to a variety of market failures that are characterized by inadequate disclosure, weak corporate governance and weak securities regulation. The combination of an undeveloped institutional framework and inefficient capital markets encourages concentrated family ownership; thus, founding families hold a majority of equity ownership of their firms to maintain sufficient control (e.g., Khanna & Palepu, 2000b). A larger proportion of ownership in the hands of few owners, such as founding families, motivates them to monitor managerial decisions, to minimize managerial agency costs (Anderson & Reeb, 2003) and to take measures to protect their firms' interests. Burkart, Panunzi, and Shleifer (2003) argue that the less that outside investors are protected legally, the greater the need for large family shareholders that can minimize the agency problem between owners and managers in an emerging market. Moreover, managers in publicly traded family firms tend to develop a reputation for not expropriating minority shareholders and, consequently, minority shareholders support the family owners because the family owners control the managers in emerging markets (Gomes, 2000). Therefore, it is expected that managers in family firms are more likely to be aligned with the founder family so that the conflict of interest between minority shareholders and family owners in India is more likely minimized.

In addition, the large shareholders of the firm can influence the allocation of scarce resources for competitive and challenging investments such as in innovation and monitor how the investments are being utilized (Hoskisson, Hitt, Johnson, & Grossman, 2002). Because of the institutional underdevelopment in the markets in India, the high level of interaction, common understanding, and natural alignment of interests between family members and employees enables the family owners to integrate any individual specialized technological knowledge either family members or employees may have (Chirico & Salvato, 2008). These firms are strongly embedded in the society (Fuller & Tian, 2006) and are often recognized as successful entrepreneurs who can communicate their new ideas more effectively with their governments. These owners can obtain social and political capital, secure the supply of raw materials, financing and

government contracts (Singh & Gaur, 2009); all of which enhance technological innovation. Their economics of scale and technological competence are far superior to other types of firms (Chirico & Salvato, 2008). They also have strong social and cultural influences in the society and maintain good links with government agencies and can thus protect their innovation technologies (patents) and products (Singh & Gaur, 2009). It is plausible that concentrated Indian family firms may focus more on utilizing resources in innovation to enhance firm performance than on expropriating minority shareholders.

In summary, although the same types of agency problems in firms of developed markets afflict family firms in emerging markets such as India (e.g., the agency problem between majority and minority shareholders, between owners and managers, or between two family firms affiliated within the same business group), we argue that the degree of such agency problems, particularly between majority and minority shareholders, are less severe. The benefits of concentrated family ownership that help overcome institutional underdevelopment and facilitate in obtaining external resources outweigh these agency costs, and these benefits are essential for technological innovation. Whereas agency theory drives the internal corporate governance mechanism, external mechanisms, such as institutional development, complement the impact of family ownership on innovation in emerging markets and promote the evolution of dynamic capabilities for innovation in family firms. We thus propose our first hypothesis:

Hypothesis 1. Family ownership in India has a positive impact on the innovation activities of family firms.

Affiliating with business groups of Indian listed family businesses enables certain institutional underdevelopment to be filled and controls certain agency problems in firms; business groups are able to perform intermediating functions and mitigate resource diversification costs.

Strong intermediary institutions provide the necessary financing, technology and management talent for innovation in developed markets (Munoz-Bullon & Sanchez-Bueno, 2011). However, these facilitating intermediary institutions are absent in emerging markets, such as India, because of institutional underdevelopment, which motivates the Indian business group to support its innovation activities. Unlike developed markets, in the emerging markets, large business groups act as intermediary institutions between family firms and the imperfect market (Khanna & Palepu, 2000b). In other words, these business groups, although they are structurally different from US conglomerates or Japanese *keiretsu* (owned by large banks), often replicate the function of stand-alone intermediary institutions in developed markets. The group-affiliated Indian family firms can obtain access to "internal capital markets" for funds and utilize group reputation for other essential external resources for innovation activities (Almeida & Wolfenzon, 2006). Khanna and Palepu (2000b) empirically show that affiliation with large Indian business groups increases firm performance by overcoming external institutional underdevelopment in the Indian market.

As a result, these business groups can also mitigate the cost of their diversification because they restrict the use of the internal capital markets to prop up inefficient operations, and transaction costs during business operations are minimized. In his seminal study on the role of the business group to mitigate capital market distortion, Leff (1976) argues that the group structure provides a mechanism to mobilize managerial talents and technological knowledge, in addition to helping affiliated firms to access internal capital markets, which addresses the need for efficient external capital markets (Almeida & Wolfenzon, 2006). Family ties within business groups can also provide unconditional trust and an organizational culture of altruism and stability, which combine to reduce transaction costs that result from information asymmetry and disputes. The success of innovation is often uncertain and invites risks that require trust and understanding among family members and employees. Intense interactions among group affiliates help to achieve trust and confidence and to increase the likelihood of sharing risks (Zahra, 2003). Therefore, affiliation with large business groups can help family firms perform more effectively in the presence of institutional underdevelopment and resolve certain information and transaction costs in emerging markets (Chu, 2004). Khanna and Palepu (2000b) show that the largest and the most diversified business groups in India perform well; in addition, they share their reputations and political connections among themselves.

Thus we develop our second hypothesis as follows:

Hypothesis 2. Business group affiliation positively influences the relationship between family ownership and innovation, such that family firms affiliated with business groups are more innovative than stand-alone family firms in India.

DATA AND VARIABLES

Data Source

Our data sources include (1) the PROWESS[1] database that is maintained by the Center for Monitoring the Indian Economy (CMIE) and (2) the PATSTAT database available through the European Patent Office. We collected ownership data from PROWESS during 2001 and 2008 and considered ownership being held by the ultimate owner listed on the Bombay Stock Exchange (BSE). These firms are required to follow norms set by the Securities and Exchange Board of India (SEBI), India's securities market regulators, in announcing financial accounts.

Sample Construction

We eliminated observations in which the reported data were not annual. In addition, we also dropped observations that had more than 50 percent foreign ownership. Further, following Chari and David (2011), we eliminated observations that showed an unusually high (above 50 percent) or low (below 50 percent) return on assets, as this information might consist of large asset selloffs or purchases.

We excluded financial institutions from our study. Financial institutions are generally professional investors with significant experience with historical returns. Thus, they act differently from individual shareholders. Naturally, institutional investors choose to invest in companies with higher

productivity potentials. In addition, because Indian banks do not belong to business groups (Khanna & Palepu, 2000b) and because we are investigating the effects of business groups on the innovation of family firms, we also excluded banks.

Because we required firms to have active R&D (i.e., firms that have filed at least one patent application), we extracted all patent information related to Indian firms from PATSTAT and found that these firms filed approximately 10,000 patents in various patent offices around the world. Because our focus is to track the innovation activities of family firms, we considered the patent filing year (*first filing*) as the reference year for our dataset. Because PATSTAT has the raw data for all patents filed in more than 80 countries around the world, the hard task is to find a common identifier to match this patent data with ownership data obtained from PROWESS. We cleaned the names of Indian firms (also with help from Magerman, Grouwels, Song, and van Looy, 2009) and took these firm names (*strings*) to match with firm names obtained from PROWESS. We used the Levenshtein distance algorithm (sometimes called edit distance) for coding and grouping firm names. This provided us with a sample of 428 matched firms that had active patents recorded in PATSTAT. Because the ownership data available from 2001 to 2008 are from the PROWESS database (2008 version), after matching the two data sets and excluding state-owned firms (in which the government holds more than 50 percent of a firm's shares) and addressing missing data and outliers in key variables, we settled on an unbalanced sample of 395 firms with 7,065 patents and other financial data for the 2001–2008 period. Although only 395 listed family firms remain, we argue that the sample does not lose representativeness for the entire population of publicly listed family firms, which are the focus of our study, for the following six reasons. First, because it is a signatory to TRIPs (trade-related aspects of intellectual property rights), India started product patenting in 2005 in many areas of technology. Therefore, before 2005 we had far less, and less complete, patent information that was mostly related to process patenting (Chadha, 2009). Second, because of India's weak institutions, such as weak patent policy, many firms have not patented their technology and innovation (Deolalikar & Evenson, 1989). Third, patent applications require large amounts of R&D investment and often require a significant amount of time to progress from application to granting patents. Therefore, we obtained patent information only for those firms that can afford these processes. Fourth, on the basis of the preceding explanation, we assume that only firms that are able to bear the cost of patenting and are well known in the financial market for their high R&D activities are providing their patent information. In India, these firms are publicly traded on the Bombay Stock Exchange; publicly listed family firms, which are the focus of this study, are the majority of these firms. Moreover, after matching 10,000 patents retrieved for Indian firms with CMIE ownership data, we obtained 7,065 patents. Therefore, we obtained 70 percent of the patents and used this information to construct the main dependent variable in our model. From this perspective, our sample is largely representative of publicly listed family firms. Fifth, there might be a possibility to model firms without any patent information by using Heckman correction and including an inverse Mill's ratio in the regression. We have tested that and found no significant differences from our reported results. Finally, our sample size is also consistent with other studies on family ownership and business groups in emerging markets. For example, Singh and Gaur (2009) used only 400 Indian firms, whereas Peng and Jiang (2010) used 634 family firms for seven emerging markets in their studies.

Variables

We considered the patent-R&D ratio as proxy for the dependent variable, *innovation productivity*, because input (research effort, such as R&D expenses) and output (patent numbers or number of products) can be observed from available data, but the intention (inventions) of the inventor or firm cannot. In addition, there is a linear homogeneous relationship between input for innovation, such as R&D expenditure, and output, such as patents or products (Coe & Helpman, 1995). Cohen and Klepper (1996) argue that R&D activities lead to invention, which eventually results in product or process innovation. To capture this effect, we followed the study of Lanjouw and Schankerman (2004) and measured innovation productivity by the number of patents per unit of R&D spending. Consistent with the existing literature (Griliches, Pakes, & Hall, 1987) and following recent studies, we also included the number of patents (Choi et al., 2012) and R&D intensity (Chen & Hsu, 2009) as proxies for innovation as dependent variables.

Following Khanna and Palepu (2000b) and Singh and Gaur (2009), we considered the percentage of shares held by the founding family as an individual or group to be a proxy for family ownership concentration, which was an explanatory variable. In addition, our estimation consisted of a dummy variable representing family firm, which was coded as 1 if the minimum threshold of family ownership of 20 percent[2] was met, and 0 otherwise. To understand the effect of business groups (business house) we calculated three interaction terms depending on whether the firm has family ownership and falls into one of the three following main categories (available from PROWESS): top 50 business groups, large business group and others. The business group is a dummy variable (1 if the firm is affiliated to any business group, and 0 otherwise) based on business group size and group activities.

A number of control variables were included. The prior literature on family business shows that "family ties" (an important intangible resource, according to the resource-based perspective) and common interest alignment and emotional attachment (*hard-to-imitate asset*) may reduce agency costs between family members and their firms (Eddleston, Kellermanns, & Sarathy, 2008). When a family member often holds the CEO position and/or serves on the board of directors (Anderson & Reeb, 2003), the family ties to the firm are strengthened. Recent studies on emerging markets also show that family CEOs are generally politically connected, which is of assistance in external funding and political bailouts (Faccio, Masulis, & McConnell, 2006). To control for the effect of family members in management and control (apart from cash flow rights), we included a dummy variable set to 1 if a member of a founding family is in the

TABLE 1
Variable Definitions

Variables	Construct
Innovation productivity	Number of patents/R&D expenses
R&D intensity	R&D expenditure/Sales
Family ownership (%)	Percentage of all classes of shares held by the family (shareholding of Individuals and Hindu Undivided Family) as an individual or as a group
Family firms	Dummy indicates 1 if founding family holds minimum of 20% shares
Family CEO	Dummy indicates 1 if founding family member(s) is CEO or in BoD
Family ownership (%)* dummy 50 BG	Interaction term indicating the top 50 business groups affiliated firms with family ownership
Family ownership (%)* dummy large BG	Interaction term indicating the large business groups affiliated firms with family ownership
Family ownership (%)* dummy other BG	Interaction term indicating the others business groups affiliated firms with family ownership
Foreign ownership (%)	Percentage of common shares owned by foreign individual, corporate bodies
State ownership (%)	Percentage of common shares owned by State Government
Firm size	Log of total sales
Firm age	Log of firm's age
Knowledge stock	Number of patents in last 4 years assuming 15% annual depreciation and an 8% growth backward in times
Wage intensity	Wage/Sales
Employee compensation	Last 5 years average employee compensation
Total assets (moving average)	Last 5 years average total assets
Industry dummy	1 if the firm belongs to Manufacturing, IT or chemical industry, 0 otherwise

The industry dummy is created by using National Industry Classification (NIC) code available in Prowess database. Patent data are obtained from PATSTAT. Ownership and Other information are obtained from Prowess.

CEO position and 0 otherwise. This measure is based on hand-collected information from the annual reports and websites of the firms. The size of the firm indicates the present and future prospects for innovation (Craig & Dibrell, 2006). Momentary increases or decreases of sales provide a signal of firms' innovation activities. We used a logarithm of sales as proxy for the *size* of the firms. The *age* of the firm is also important. Many studies on innovation have used the number of scientists, employees or age of the firm in this respect. We adopted a logarithm of age to control for the experience of the firm, following Cohen and Klepper (1996). The resource dependence perspective suggests that firm-level intangible resources influence innovation activities. *Knowledge stock*, an important intangible resource, significantly contributes to the distributed lag of current and past innovation activities (Blundell et al., 1999) because innovation depends largely on combinations of existing technological knowledge. Thus, we used the last 4 years' patent numbers (calculated by the perpetual inventory method) to control for the effect of innovative knowledge stock. The corporate governance literature shows that foreign ownership of a firm indicates a significant extent of knowledge transfer from the international environment to that firm (Fernandez & Nieto, 2006). Therefore, we controlled for the shares of family firms owned by foreign corporate bodies and institutions. Chang, Chung, and Mahmood (2006) show that state-owned firms have significant access to important infrastructure provided by the innovation policy of their government. Therefore, we also controlled for the percentage of governmental shareholding. Family firms in business groups can be a single and independent legal entity or conglomerates that operate in different sectors. Unlike conglomerates, family group firms often share structural features across firms (Khanna & Yafeh, 2005) that affect innovation. Therefore, we used firm-level data and not conglomerate-level data. Because different industries have different technological and learning regimes that affect the innovation capabilities of firms, we controlled for the industry effect by constructing *industry dummies* that were equal to 1 if the firm belonged to the manufacturing, information technology or chemical industries and 0 otherwise. These industries were chosen as they have the most number of patents in the sample. SEBI implemented a new regulation in 2006 that requires listed firms to disclose detailed information on corporate governance and equity and share holdings. We, thus, used two year-span dummies for the 2001–2005 period and the 2006–2008 period. Table 1 provides definitions of variables and data sources.

From the innovation literature, it is widely accepted that technological knowledge spillovers and factor demands are substitutes for one another because this flow decreases labor costs (Van Reenen, 1997). In a family business, in which

lower levels of management hierarchy exist, employee compensation costs at the operational level are consequently higher than in non-family firms. Werner, Tosi, and Gomez-Mejia (2005) find that the compensation strategy is a function of ownership structure. Therefore, we used the average *compensation* and *wage intensity* (measured by wages over sales) over the last 5 years as instruments. In addition, we also included the last 5 years moving average assets of the firm as another instrument. Along with these three instruments, we instrumented the endogenous regressor, i.e., family ownership in the system-GMM model, by a variable *business risk* that was constructed from the standard deviation of sales divided by total assets because family firms affiliated with business groups generally diversify business risks among group members.

Specification of Econometric Model

Because most empirical corporate governance studies show both positive and negative effects of family ownership on firm innovation, King and Santor (2008) recently argued that this might be because of misspecifications of the model (simultaneity) and incorrect model estimation because of unobserved firm heterogeneity that biases the results. These factors are recognized as a potential source of endogeneity.

To solve the endogeneity problem in this study, we aim to improve the existing econometric model in empirical corporate governance literature by revising the basic knowledge production (for innovation) model used in the innovation literature. Specifically, to examine the relationship between family ownership and innovation, we begin with the knowledge production function developed by Griliches (1979) and then modify it according to our research questions.

The knowledge production function we have undertaken is generally used to examine the impact of investment on a firm's R&D and patent applications. Prior studies have estimated a "static" model of the form: *innovation = f(ownership percentage, firm characteristics, fixed effects)*, that can be formally written as:

$$Y_{it} = \beta_0 + \beta_1 Z_{it} + \lambda_t V + S_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is the innovation productivity of firm i in time t because of the input for innovation (e.g., percentage change in share holdings) of the firm, assuming that the firm maintains other input factors constant over the period of this study. β_1 captures the effect of the percentage of shares held by owners of the firm and Z_{it} is a vector of firm-specific factors that determine the ownership structure that are assumed to be associated with innovation activities (directly or indirectly) and includes the treatment variables. V indicates industry dummies, whereas S_t implies the dummies for each time span (not exactly a time counter, but a time counter of each period, e.g., 2001–2005 and 2006–2008). ε_{it} is the idiosyncratic error and is an unobservable term of firm i in time t.

Analytical Techniques

Following the previous studies on family businesses (e.g., Villalonga & Amit, 2006), we began with traditional fixed- and random-effect models. The panel nature of our data allows us to control for any unobserved variables (e.g., institutional differences) that change over time but not across family firms. We used fixed effects to control for unobserved heterogeneity. The effect of the time invariant covariates did not appear in fixed-effect regression models (not reported) because the effect is cancelled out by the within transformation. Therefore, it is difficult to identify whether family firms hold more shares (i.e., more cash flow rights) as a result of superior performance of the firm or because of the return on their investment (including personal wealth) to the firm because successful innovations may trigger more investment in the firm. If simultaneity exists, the family ownership variable would be biased upward. In the fixed-effects model, we permitted the family ownership variables to be correlated with random individual specific effects, which should minimize the endogeneity. Thus, if the decision of family ownership is correlated with certain unobserved variables, we can assume that they are correlated with only time-invariant components of the unobserved variable that are captured by the individual family firm-specific effects. In other words, the fixed-effects model might give us consistent estimates of the marginal effect of regressor, provided the regressor is time varying (even if it is endogenous). As an alternative, following Gaur and Kumar (2009), we used random-effects estimations of the level equation (1), and these are reported in Table 4. The random-effects models provide more efficient estimates than the fixed-effect models in the absence of any correlation between time-invariant unobserved heterogeneity and the regressors. This model allows us to examine the variations among cross-sectional units simultaneously with variations among individual units over time. The Hausman test shows the justification of using the random-effect models.[3]

Addressing Endogeneity Issues

A large number of empirical studies on corporate governance recognize ownership structure as an endogenous variable (Demsetz & Villalonga, 2001). We find that the coefficient of family ownership is not robust to inclusion of fixed effects (industry or firm). That is, family ownership and innovation are determined by common factors, some of which are unobservable to econometricians. Moreover, the family owners of a firm would prefer to obtain all inputs for innovation without any problem. For instance, Munari, Oriani, and Sobrero (2010) show that managers are likely to prefer a firm's resources to low-risk R&D projects. In fact, because the family owners might have insider information about their firm, performance-based compensation would influence the innovation outputs. Therefore, expected innovation and technological progress can also shape the family ownership structure, which leads to reverse causality. In the current context, this endogeneity problem may also occur because the current value of family ownership is a function of the past innovation of the firm. Thus, the regression results would be spurious if we do not carefully address these endogeneity concerns.

We respond to the endogeneity problem by rewriting our empirical model (1) as the following: *innovation = f(past innovation activities, ownership percentage, firm characteristics, fixed*

effects), which leads us to the following two broad goals of this study: (1) to understand the "dynamic" relationship between family ownership and innovation and (2) to estimate this dynamic model in this context. These issues can be addressed through several approaches by following prior studies in similar situations. For example, Smith, Cin, and Vodopivec (1997) control for simultaneity by analyzing the data with two-stage Tobit least-squares methods, whereas Mueller, Dietl, and Peev (2003) use a binary logit regression. Generally, compared to the average investors families (or promoters), have longer stakes in their firms, which allows them exceptional foresight in predicting future firm performance (Anderson & Reeb, 2003). Thus, family ownership is potentially correlated with all error terms, time varying components and firm-specific fixed effects. In recent years, Benfratello and Sembenelli (2006) have used an IV-GMM technique to examine foreign ownership on total factor productivity of Italian manufacturing firms. Becuase the instruments help find the exogenous variables uncorrelated with the dependent variable and strongly correlated with the endogenous variables, the IV-GMM estimator solves the moment conditions that impose orthogonality between the error term and the set of instruments (including the exogenous regressors).

In this study, we address endogeneity in two phases. In the first phase, we adopt the two-stage least square (2SLS) estimator (without including the past innovation activities of firms) using the following three instruments: last 5 years total assets, employee compensation, and wage intensity (see Table 1 for definition). The regressions show us the positive effects of family ownership on innovation productivity, as opposed to the random-effects panel models reported in Table 4. However, the results are not statistically significant; nonetheless, it provides some indication that support the instruments.

In the second phase, we apply a dynamic generalized method of moment (GMM) estimator as proposed by Arellano and Bond (1991)[4] to our panel to estimate the relationship between family ownership and innovation. Unlike 2SLS or random- (or fixed-) effects panel regression – because current innovation activities are influenced by past family ownership and associated innovation – it may be possible to use some combination of variables from a firm's history as a valid instrument in this dynamic GMM to account for simultaneity (Wintoki, Linck, & Netter, 2012). Thus, the use of "internal" instruments contained within the panel itself eliminates the search for external instruments. Moreover, unlike ordinary least square (OLS) estimation, we can include firm-fixed effects to account for time-invariant unobserved heterogeneity.

Therefore, we further improve our model following a similar model by Shyam-Sunder and Myers (1999). The model is presented below and the derivation is shown in the appendix.

$$Y_{it} = \sum_{p} \xi_p Y_{i(t-p)} + \sum_{i} \alpha_i Z_{k,it} + \mu_{it} + \delta_k + d_t + \varepsilon_{it}, \quad p > 0 \qquad (2)$$

In this model, we consider the lags in innovation and for unobserved individual factors that are time-variant by allowing $\mu_{it} = n\mu_{i(t-1)} + e_{it}$ to be the first-order autoregressive process, $|n| < 1$.

In particular, the basic estimation has the following two steps: we use a difference-GMM estimator (Blundell & Bond, 1998) that allows us to eliminate the potential endogeneity because of time invariant unobserved heterogeneity. The first differenced model (3) is estimated by GMM using the lagged values of independent variables as instruments.

$$\Delta Y_{it} = \sum_{p} \xi_p \Delta Y_{i(t-p)} + \sum_{i} \alpha_i \Delta Z_{k,it} + \Delta\mu_{it} + \Delta\varepsilon_{it}, \quad p > 0 \qquad (3)$$

However, Arellano and Bover (1995) note that that the variables in levels may be weak instruments for first-differenced models. Therefore, to overcome this problem, we include the equations in levels in the estimation methods. In other words, the first-differenced variables are used as instruments for equations in levels in a system of equations that includes the equations in both levels and differences (Wintoki et al., 2012). This method is called system-GMM estimation.

EMPIRICAL RESULTS

The collinearity test indicates that none of the variables has a variance inflation factor (VIF) greater than 5, which rules out multicollinearity. Tables 2 and 3 represent the correlation matrix and the summary statistics, respectively, of the continuous variables of interests. From the correlation matrix, we see that family ownership is positively correlated with innovation productivity. Moreover, family ownership is negatively associated with size (total sales) and age of the firm. This suggests that older firms invest more in invention activities.

The summary statistics from 395 listed firms show that 278 firms are family owned and 197 firms are affiliated with business groups. Families in family firms hold a maximum of 80 percent of shares, whereas the group-affiliated family firms hold a maximum of 72 percent of equity shares. Obviously, firms holding more than 72 percent are stand-alone firms. In terms of innovation activities, the mean of innovation productivity and R&D intensity are higher for the stand-alone firms compared to business groups. Notably, family firms are younger than non-family firms, whereas total sales and total assets are lower in family firms than in non-family firms. We have also performed a *t*-test of the difference of means and the findings show that most of the variables are statistically significant.

Table 4 shows the general linear square (GLS) random-effects model estimation of equation (1), in which the results are documented separately for the group firms and stand-alone firms. The coefficients of overall family ownership (including both group-affiliated and stand-alone firms) are negative for both the number of patents and innovation productivity. This is consistent with results from the previous studies on emerging markets (Chen & Hsu, 2009) and on developed economies (Munoz-Bullon & Sanchez-Bueno, 2011), which find a significant and negative relationship between family ownership and innovation. Although the model may explain large variations in the data, which are

TABLE 2
Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Innovation productivity (1)	1.00							
Family ownership (%) (2)	.12*	1.00						
Foreign ownership (%) (3)	.03*	−.01*	1.00					
Knowledge stock (4)	.04***	.02*	−.02*	1.00				
Total sales (5)	−.03	−.05	−.02	−.05	1.00			
Firm age (6)	−.07**	−.13***	.01	.08	.10***	1.00		
Total assets (7)	−.04	−.05*	−.03	−.04	.83***	.11***	1.00	
Employee compensation (8)	−.04	−.04	−.02	−.07	.42***	.10***	.55***	1.00

The numbers listed horizontally across the top row correspond to the number and variables listed vertically on the table.
***, ** and * represent a .1%, 1% and 5% significance level using two-tailed test, respectively.

indicated by high R^2, the estimates might be heavily biased because of unobserved heterogeneity (becuase Z_{it} and ε_{it} are correlated). Suppose the idiosyncratic error varies over individuals and time, such that $\varepsilon_{it} = v_i + u_{it}$, where v_i is the founding family specific time-invariant unobserved heterogeneity, e.g., unobserved family culture that remains constant over time. However, the estimates continue to violate the assumption of random-effects estimators that Z_{it} is uncorrelated with both v_i and u_{it}.

The firm's dominant shareholders, in general, give importance to human capital to shape managerial decisions to allocate resources efficiently, particularly during an economic crisis. Feliciano and Lipsey (1999) give importance to the wage differentials between domestic- and foreign-owned firms. Thus, we used three instruments – the last 5 years average of total assets of the firm, the last 5 years average of employee compensation and the wage intensity (as computed by executives and employees salaries, bonuses, and other benefits over total sales of the firm) – for the family ownership. Table 5 reports the two-stage least squares (2SLS) instrumental variable regression. For the relevance of the instruments used, we report the first stage regression summary in Table 5, which shows that at least one instrument is significant at the .1 percent level. The validity of the instruments was also checked with the Durbin-Wu-Hausman test. Under the null hypothesis, the endogeneity should not affect the OLS estimator (not reported), which indicates β_{OLS} is consistent and efficient, whereas β_{IV} is consistent but inefficient. However, model 3 of Table 5 shows the rejection of family ownership exogeneity. We employed three instruments for the family ownership variable. If at least one instrument is valid, then it is necessary to test whether other instruments are uncorrelated with the error term in the second stage. From the test reported in Table 5, we could not reject the over-identifying restriction. Instead, we expect either all or no instruments to be valid. In Table 5 (models 2 and 4), we also report the limited information maximum likelihood (LIML) estimator to rule out the presence of weak instruments. Although the 2SLS regression indicates that no family ownership variable is significantly associated with firm innovation, it supports the argument that family ownership and family CEO are endogenously determined. Moreover, we have a good indication that there is a positive impact of family ownership concentration on innovation productivity.

From equation (1), one may argue that the causality may run in both directions, e.g., higher productivity may offer an incentive to family owners to invest more in R&D or with the help of more investment in innovation activities, productivity may be increased. Thus, the regressors are correlated with the error terms. In this case, the fixed-effects instrumental variable regression might be effective. However, the first stage statistics of the regression (results in Table 5) show that the instruments are weak and consequently a biased estimator is obtained. Therefore, in the presence of the non-iid (independent and identically distributed) errors, we used system-GMM[5] for equation (2) as developed by Arellano and Bover (1995) and Blundell and Bond (1998). The GMM estimators, reported in Table 6, give consistent and efficient estimates because the moment conditions use an optimal weighting matrix that maximizes its asymptotic variance (see Baum, Schaffer, & Stillman, 2003). Moreover, with additional instruments for the equation in levels, system-GMM is more efficient than difference-GMM. We further controlled for unobserved heterogeneity between large and small firms by allowing an autoregressive component in the error term.

In Table 6, we included three proxies for innovation, namely number of patents, R&D intensity and innovation productivity. We found that family ownership concentration is positively associated with innovation outcome of the sample firms (e.g., model 5: $\beta = .01$, $p < .05$ and model 6: $\beta = .03$, $p < .001$). However, the coefficient of family ownership is negatively correlated with the number of patents, as shown in models 1 and 2 (model 1: $\beta = -.27$, $p < .05$ and model 2: $\beta = -.22$, $p < .001$). We thus further analyzed the interaction effects of family ownership concentration and a dummy denoting the subset of family ownership with a threshold value of 20 percent shareholding and find that the role of family ownership is consistent with the existing literature (Faccio & Lang, 2002). The result of model 6 in Table 6 provides support for hypothesis 1 by indicating that family ownership concentration positively affects the innovation productivity of publicly listed family firms at the .1 percent significance level (model 6: $\beta = .17$, $p < .001$), which

TABLE 3
Summary Statistics

(A) Number of firms	Family firms 278			Non-family firms 117			T-Test
	Mean	SD	Max	Mean	SD	Max	Diff
Innovation productivity	.62	2.74	41.18	.59	3.75	60.00	.03*
R&D intensity	.10	3.12	125.60	.01	.02	.19	.09
Number of patents	3.04	9.92	113.00	2.75	20.10	282.00	.29*
Family ownership (%)	5.69	14.16	80.18	.45	2.13	19.17	5.24***
Indian corp. promoters (%)	4.90	14.23	78.58	3.53	11.71	73.70	1.37***
Foreign corp. promoters (%)	.92	5.81	90.00	2.67	11.61	76.00	–1.75**
Knowledge stock	287.25	314.44	1,645.48	387.68	999.49	4,509.43	–100.40**
Firm size	1,181.57	6,266.81	139,269.46	4,495.78	20,315.20	270,582.36	–3,314.20
Total assets	1,404.74	6,982.89	150,149.41	3,670.76	13,466.44	136,872.50	–2,266.00**
Firm age (years)	32.71	20.28	108.00	43.77	20.00	90.00	–11.06**
Employee compensation	106.59	549.56	9,553.51	231.62	711.03	8,069.15	–125.00**
(B) Number of firms	Group firms 197			Stand-alone firms 198			T-Test
	Mean	SD	Max	Mean	SD	Max	Diff
Innovation productivity	.60	3.45	60.00	.63	2.72	41.18	–.03*
R&D intensity	.02	.08	1.21	.12	3.63	125.60	–.10*
Number of patents	4.34	18.89	282.00	1.56	5.79	69.00	2.79**
Family ownership (%)	2.45	9.35	72.02	4.19	12.15	80.18	–1.73**
Indian corp. promoters (%)	7.40	16.24	78.58	1.55	6.44	66.32	5.85***
Foreign corp. promoters (%)	1.16	6.42	51.59	2.47	11.48	90.00	–1.31**
Knowledge stock	390.42	708.99	4,509.43	181.01	187.8	821.96	209.40***
Total sales	1,699.18	7,299.98	139,269.46	2,795.06	16,410.78	270,582.36	–1,095.90*
Total assets	1,898.09	8,022.15	150,149.41	2,368.95	10,976.94	136,872.50	–470.90**
Firm age (years)	39.58	22.08	108.00	33.01	18.97	90.00	6.57***
Employee compensation	140.84	578.88	9,553.51	152.79	637.58	8,069.15	–11.95**

Total number of firms 395. Family firms refer to those where the found families hold more than 20% of shares or the founding family members are in CEO position. Group firms are firms affiliated to business groups.
T-test for statistically significant difference in means of two samples.
***, ** and * represent a .1%, 1% and 5% significance level using two-tailed test, respectively.

is consistent with the literature discussed in the hypothesis development section. With respect to the institutional perspectives that focus on the origin of business groups because of the weak institutional framework in India, we examined the role of business group affiliation of these family firms. Hypothesis 2 predicted that business groups have a positive influence on family firms promoting innovation. Our findings show that the family firms affiliated with only the top 50 business groups play a positive and significant role in innovation productivity, as reported in model 7. Thus, all other things being equal, this result is consistent with our prediction in hypothesis 2 (model 6: $\beta = .16$, $p < .01$). In model 10 we tested our hypotheses in a full model by including all the independent variables. We found that there was an improved effect of family ownership and affiliation with business group on innovation. The p-value of the first- and second-order autocorrelation tests (z_1 and z_2) indicates no second order serial correlation and the Sargan test confirms that all the instruments (average assets for the last 5 years; average employee compensation for the last 5 years, and the lagged value of all the regressors) support the analysis.

Several results of the control variables are notable. Models 6–10 show that the variable *family CEO* negatively impacts innovation productivity. This result supports the agency theory that too dominant family control (or possible CEO duality) has a negative influence on innovation activities of firms and is consistent with previous studies (e.g., Chen & Hsu, 2009). We reported these results in models 6–9 (e.g.,

TABLE 4
Effect of Family Ownership on Innovation Productivity

Dependent variables	Number of patents			Innovation productivity		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(A) Group firms						
Family ownership (%)	−.12** (.15)	.16 (.15)	−.27* (.67)	−.17* (.02)	−.12* (.05)	−.05 (.07)
Family ownership (%)* dummy family holding min 20%			.56 (.64)			.08 (.07)
Family CEO		−1.17 (4.19)	−1.21 (4.19)		.19 (.81)	.20 (.81)
Firm size	1.66 (1.35)	1.69 (1.35)	1.56 (1.36)	−.46* (.25)	−.42* (.26)	−.51* (.26)
Firm age	−.93 (2.85)	−1.29 (3.14)	−1.35 (3.14)	.30 (.52)	.48 (.58)	.38 (.58)
Knowledge stock	.07*** (.09)	.05*** (.07)	.05*** (.02)	.10 (.12)	.11 (.08)	.09 (.21)
Foreign ownership (%)	−.26 (.25)	−.25 (.25)	−.20 (.26)	.09 (.03)	.09 (.03)	.10 (.03)
Constant	−16.76 (12.94)	−15.08 (14.32)	−11.74 (14.75)	3.97 (2.15)	3.74 (2.38)	4.00 (2.42)
Observation	178	178	178	164	164	164
R-Squared	.73	.74	.74	.14	.11	.14
Wald χ^2	475.24***	472.66***	473.26***	33.96***	34.88***	31.24***
(B) Standalone firms						
Family ownership (%)	−.14* (.09)	−.10 (.09)	.06 (.25)	−.19* (.07)	−.19* (.11)	−.18 (.13)
Family ownership (%)* dummy family holding min 20%			−.15 (.22)			−.06 (.11)
Family CEO		8.27* (4.13)	8.41 (4.43)		−2.35 (1.72)	−2.34 (1.72)
Firm size	1.29* (.65)	1.80** (.69)	1.80* (.73)	−1.21** (.35)	−1.27** (.41)	−1.23** (.40)
Firm age	−12.31** (4.14)	−11.27** (4.13)	−11.20* (4.45)	2.13 (1.62)	2.15 (1.73)	2.24 (1.75)
Knowledge stock	.00 (.01)	−.00 (.01)	−.01 (.01)	.00 (.00)	.03 (.00)	.01 (.00)
Foreign ownership (%)	.20* (.10)	.27** (.10)	.28** (.11)	−.14 (.04)	−.11 (.04)	−.07 (.04)
Constant	6.96** (13.13)	5.98 (14.17)	4.90 (15.45)	.15 (5.64)	.56 (6.36)	.08 (6.57)
Observations	62.00	62.00	62.00	58.00	58.00	58.00
R-Squared	46.51	51.39	48.87	31.19	32.65	33.19
Wald χ^2	29.25***	34.81***	34.27***	22.73**	24.37**	23.95**

The sample is an unbalanced panel of 395 firms that filed 7,065 patents in different patent offices around the world during 2001–2008. The observation used is 2,396.
All models are estimated by GLS random-effect regressions. Cluster-robust standard errors are shown in parentheses.
Family ownership (%) variable is measured as the percentage shares held by Indian individual and Hindu undivided families (as individual or group). In all models Industry and year effect are included but not shown.
***, ** and * represent a .1 percent, 1 percent and 5 percent significance level using two-tailed test, respectively.

model 6: $\beta = -.35$, $p < .001$). *Firm size* shows a negative and significant impact on innovation productivity. This might imply that strong reliance of family trust decreases as the firm grows and this further decreases the effects of family control on innovation. Although small firms may have difficulty in securing adequate collateral to obtain external financing for innovation, affiliating with business groups provides them with the ability to access internal capital markets. Thus, consistent with the literature on developed countries (Acs & Audretsch, 1988), small and medium size enterprises (SMEs) are more innovative than large firms in emerging markets. Moreover, these SMEs are much faster to react to the changing and emerging technological market niches than large firms. However, in our study, family firms are not necessarily SMEs. Thus, it is possible that as a family business grows, it becomes more diversified, which may affect its innovation activities.

Robustness Checks

In the robustness tests, we report the coefficients estimated with different specifications of the variables in Table 7. We checked 10 percent and 30 percent threshold values of stakeholdings by the founding family of the firms. In both cases, we found a positive impact of family ownership on innovation (model 1: $\beta = .02$, $p < .001$ and model 2: $\beta = .08$, $p < .05$). In our data, we found that approximately 40 percent of total firms belong to the manufacturing industry. Thus, we con-

TABLE 5
Effect of Family Ownership on Innovation

Dependent variables	Number of patents		Innovation productivity	
	2SLS Model 1	LIML Model 2	2SLS Model 3	LIML Model 4
Family ownership (%)	2.72 (2.66)	3.80 (3.85)	2.58 (7.66)	.33 (.22)
Family CEO	−.49 (5.03)	−.72 (5.24)	−.80 (2.07)	−.41 (.43)
Family ownership (%)*Family firms	−2.28 (2.46)	−3.30 (3.58)	−2.43 (7.18)	−.32 (.20)
Firm size	3.02* (1.27)	3.12* (1.40)	−.13 (1.06)	−.38* (.18)
Firm age	−.07 (3.82)	−.16 (4.23)	.81 (2.39)	.14 (.27)
Knowledge stock	.05*** (.01)	.05*** (.01)	−.00 (.00)	−.00 (.00)
Foreign ownership (%)	−.31 (.38)	−.40 (.48)	−.37 (1.06)	−.06 (.04)
Constant	−45.84 (27.80)	−48.67 (31.82)	−6.90 (33.53)	2.73 (2.23)
Observations	161	161	148	148
Durbin-Wu-Hausman				
χ^2 *(1)*	32.67 (p = .10)		25.499 (p = .01)	
F	12.28 (p = .13)		14.175 (p = .04)	
Over identifying restriction				
χ^2 *(2)*	3.79 (p = .15)		5.392 (p = .26)	
First stage regression				
Adjusted R-squared	.97	.96	.96	.97
F (*P*)	12.25 (.00)	10.25 (.04)	12.31 (.01)	9.31 (.00)

The sample is an unbalanced panel of 197 firms affiliated to business groups during 2001–2008.
All models are estimated by 2SLS and LIML regressions. Asymptotic standard errors robust to heteroscadasticity are shown in parentheses. Family ownership (%) variable is measured as the percentage shares held by Indian individual and Hindu undivided families (as individual or group). In all models Industry and year effect are included but not shown.
The instruments applied for the equation are last 5 years average total assets, last 5 years average employee compensation and wage intensity (wage/total sales). Only firms affiliated to Business groups have been considered here.
***, ** and * represent a .1 percent, 1 percent and 5 percent significance level using two-tailed test, respectively.

trolled for this particular industry to ascertain whether our results were driven by it. The results (models 1 and 2) are consistent with the previous findings. As discussed in the theoretical framework, financial and accounting data, including ownership structure, become more precise after the amendment of the disclosure rule in 2005–2006. To capture this effect, we included two dummy variables that indicated the two periods, i.e., 2001–2005 and 2006–2008. In model 4, we found that the effect of family ownership on innovation productivity with a minimum of 20 percent stakeholdings substantially increased after 2006 (model 4: $\beta = .31$, $p < .01$). The results for non-family firms (in which family owners hold less than 20 percent of equity) are also reported in columns 5 and 6 of Table 7.

For emerging and transitional economies, foreign partners often provide domestic firms with advanced technology, management skills and other resources beyond financial support (Choi et al., 2011). Studies on Chinese firms show that an increase in foreign ownership is positively related with successful industrial growth (Peng, 2000). In India, with a large proportion of family firms, the government allows the entry of foreign MNCs to access advanced foreign technology. Foreign ownership also acts as a crucial driver for reform in corporate governance and institutional framework development in emerging markets (Choi et al., 2011). Moreover, in emerging markets, governments facilitate technology absorption among local firms through various support policies (Mahmood & Rufin, 2005). Chang et al. (2006) show that state-owned firms have significant access to important infrastructure provided by governmental innovation policy, although the nature of government's choices is driven by both social and political goals. Therefore, in emerging markets, state ownership can provide greater protection to shareholders when legal protection for minority shareholders is weak (Sun, Tong, & Tong 2002). Thus, the government acts as a mediator to minimize the agency problem when it is linked with firms through equity holding. This is the case in India where the majority of family ownership takes advantage of both foreign partners and the government. We found that foreign and state ownership are both positively associated with innovation output in family firms.

Although we attempt to investigate the effects of family ownership on innovation (measured by patents-to-R&D expenses ratio), it is also notable to test the effects of those family firms without active patent information. Thus, there might be a possibility in modeling firms without any patent information by using a Heckman correction and including an inverse Mill's ratio in the regression. We performed that

TABLE 6
Effect of Family Ownership on Innovation (Only Business Group Affiliated Firms)

Dependent variable	Number of patents		R&D intensity		Innovation productivity					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Number of patents $_{(t-1)}$	.21*** (.16)	.21*** (.00)								
R&D intensity $_{(t-1)}$			.56** (.17)	.52** (.19)						
Innovation productivity $_{(t-1)}$					.29** (.09)	.32*** (.03)	.32*** (.03)	.25*** (.03)	.26*** (.03)	.27*** (.03)
Family ownership (%)	−.27* (.11)	−.22*** (.01)	.01 (.00)	.01 (.00)	.01* (.00)	.03*** (.01)	.03** (.01)	.01* (.06)	−.01** (.03)	.04** (.07)
Family ownership (%)* Family firms		−2.59** (.91)		−.01 (.05)		.17*** (.05)	.07*** (.71)	.03 (.13)	.10 (.36)	.12*** (.52)
Family ownership (%)* dummy top 50 BG							.16** (.08)			.19* (.15)
Family ownership (%)* dummy large BG								−.06 (.06)		−.06 (.09)
Family ownership (%)* dummy others BG									−.04 (.09)	
Family CEO		.96*** (.61)		.02 (.01)		−.35*** (.03)	−.34*** (.04)	−.25** (.07)	−.23*** (.06)	−.25*** (.07)
Firm size	−.29 (1.29)	−.84*** (.06)	−.00 (.00)	−.00 (.00)	−.09 (.08)	−.08* (.03)	−.08* (.04)	−.11** (.03)	−.10** (.03)	−.09** (.03)
Firm age	−1.13 (2.48)	1.09*** (.25)	−.02 (.01)	−.01 (.00)	.12 (.16)	−.16** (.05)	−.14** (.05)	−.15 (.08)	−.16 (.08)	−.18* (.09)
Knowledge stock	−.02* (.01)	−.01*** (.00)	.00*** (.00)	.00** (.01)	−.00 (.05)	−.00** (.10)	−.00*** (.00)	−.00** (.00)	−.00* (.00)	−.04* (.00)
Foreign ownership (%)	.02 (.06)	.02 (.09)	.02 (.02)	.02 (.03)	.05 (.28)	.06 (.30)	.12 (.35)	.14 (1.17)	.36 (1.17)	.39 (1.19)
Sargan	147.49	149.33	152.78	153.66	213.82	222.51	254.24	230.30	229.50	231.26
Df	23	29	24	29	24	28	33	33	33	34
p-Sargan	0	.01	.02	.05	.00	.00	.01	.06	.05	.02
z_1	.07	.01	.07	.07	.01	.01	.03	.02	.02	.00
z_2	.19	.19	.62	.62	.65	.87	.45	.30	.27	.41

The sample is an unbalanced panel of 197 firms that filed patents in different patent offices around the world during 2001–2008. All columns are estimated by system-GMM estimator. Asymptotic standard errors robust to heteroscadasticity and autocorrelation of arbitrary form are shown in italics. For instruments see notes to Table 4 and an additional instrument business risk. z_1 and z_2 shows the p-values of tests for first and second order serial correlation in the differenced residuals (Arellano and Bond tests for AR(1) and AR(2) that are distributed as N(0,1) under the null of no serial correlation. The Sargan tests for over-identifying restrictions, computed as two-step estimates, is asymptotically distributed as a χ^2 under the null of instrument validity. Degrees of freedom and p-values are also reported. Family ownership (%) variable is measured as the percentage shares held by Indian individual and Hindu undivided families (as individual or group). In all models Industry and year effect are included but not shown.
***, ** and * represent a .1 percent, 1 percent and 5 percent significance level using two-tailed test, respectively.

TABLE 7
Robustness Checks

Dependent variable	Innovation productivity					
	Business groups				Stand-alone	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Innovation productivity $_{(t-1)}$	.37*** (.01)	.37*** (.01)	.41*** (.03)	.37*** (.02)	.29* (.32)	.49** (.13)
Family ownership (%)	.02*** (.01)	.01** (.05)	.09** (.03)	.08** (.03)	.02 (.03)	.03 (.02)
Family ownership*Family firm (holding 10% equity)	.02*** (.00)					
Family ownership*Family firm (holding 30% equity)		.08* (.00)				
Family ownership*Family firm (holding 20% equity)			.29** (.15)	.31** (.13)	–1.04 (1.04)	–1.56 (1.02)
Family CEO	–.14** (.04)	–.04 (.04)	–.04* (.04)	–.01** (.04)	.51 (1.27)	.44 (.57)
Firm size	–.18*** (.01)	–.21*** (.02)	–.17*** (.02)	–.22*** (.02)	–.54 (.31)	–.39* (.19)
Firm age	–.22*** (.03)	–.28*** (.04)	–.17*** (.03)	–.25*** (.04)	2.20 (1.55)	2.45 (1.17)
Knowledge stock	–.00 (.00)	.00*** (.00)	.00 (.00)	.00** (.00)	.00 (.00)	.00** (.00)
State ownership (%)	2.57*** (.15)	3.27*** (.27)	2.42*** (.39)	3.38*** (.32)	.01 (.01)	–.01 (.01)
Foreign ownership (%)	.01*** (.00)	.01*** (.00)	.01*** (.00)	.01*** (.00)	.00 (.01)	–.01 (.01)
Manufacturing inds.	–1.53 (1.15)	–1.64 (1.42)	–1.16 (1.27)	–2.18 (1.22)		
Year 2001–05 dummy			.23*** (.04)		1.37** (.37)	
Year 2006–08 dummy				.09*** (.02)		.07 (.27)
Constant	3.82** (1.12)	4.22** (1.39)	2.91* (1.27)	4.74*** (1.20)	–3.74 (3.63)	–5.28 (3.27)
Observation	135	135	135	135	54	54
Sargan	127.00	119.99	118.72	130.09	125.78	132.44
Df	26	26	25	25	30	21
p-sargan	.03	.01	.04	.02	.02	.00
z_1	.00	.05	.00	.04	.06	.03
z_2	.62	.37	.44	.29	1.00	.96

The sample is an unbalanced panel of 197 group firms and 198 stand-alone firms in 2001–2008.
All columns are estimated by system-GMM estimator. Asymptotic standard errors robust to heteroskadasticity are shown in italics. The instruments applied for the equation are as Table 5. z_1 and z_2 shows the p-values of tests for first and second order serial correlation in the differenced residuals (Arellano and Bond tests for AR(1) and AR(2)) that are distributed as N(0,1) under the null of no serial correlation. The Sargan tests for over-identifying restrictions, computed as two-step estimates, is asymptotically distributed as a χ^2 under the null of instrument validity. Degrees of freedom and p-values are also reported. In all the models, year and industry dummies are included, if not specified.
***, ** and * represent a .1 percent, 1 percent and 5 percent significance level using two-tailed test, respectively.

exercise and found no significant differences from our reported results (Table 6). In summary, our results are robust.

CONCLUSION

Main Findings and Implications

Existing studies highlight the need to investigate ownership structures and innovation in the context of institutional pressures to address the limitations of agency theory (Miller, Le Breton-Miller, & Lester, 2013). Our study provided empirical support for this relationship from emerging markets, such as India, in which the institutional framework is not well developed. We made three important contributions to the literature on family ownership and innovation. First, we examined the direct effect of family ownership on innovation of Indian listed family firms and showed that the institutional and external-resourcing perspectives might complement agency theory in a better way in this context. Second, we offered insights about how a business group affiliation of family firms influences the relationship

between family ownership and innovation in India. Third, we adopted a more rigorous econometrics method by providing a panel analysis using a system-GMM estimator and addressed endogeneity thoroughly, which therefore significantly improved the shortcomings of methodologies used in the previous literature.

Using an unbalanced panel of 395 BSE-listed Indian firms during 2001–2008, we found that, after controlling for possible endogeneity, the impact of family ownership on innovation productivity is positive. We further emphasized the business group affiliation of family firms and distinguished between innovation activities of group-affiliated and standalone family firms. We found that affiliation with the top 50 business groups increased the innovation activities of these family firms.

Our results provide positive empirical support for the theoretical argument that Indian firms with majority family ownership may perform well with respect to innovation (Mueller & Philippon, 2011). The positive association between family ownership and innovation further supports the findings of Sraer and Thesmar (2007) that family-owned firms are less sensitive to industry shocks. Furthermore, using the period dummy for 2006–2008, we provided empirical evidence that after the disclosure rule reform in 2005–2006, the positive impact of family ownership on innovation (shown in robustness checks) is stronger than in the previous period (2001–2005). This indicates that when more family firms become publicly listed and new disclosure rules are implemented, their true potential for innovation and financial performance might be better revealed. Therefore, our findings suggest that the Indian government should improve policies on information disclosure and establish more proper corporate governance mechanisms for family businesses.

Our study also provides empirical evidence for the argument of CEO duality. Wong, Chang, and Chen (2010) and Anderson and Reeb (2003) find in developed markets that, if any member of the founder family serves as CEO or controls the majority of board seats, the stock of the firms reacts negatively in the stock market. Our study shows that family CEOs reduce innovation activities in India and thus provides evidence against CEO duality from an emerging market perspective. This also supports the evidence for tunneling in India (Bertrand et al., 2002) because strong family control may motivate the family to expropriate investments for R&D. However, the reason for this negative relationship may not be caused by the agency perspective as it is understood in developed economies, but from institutional and cultural perspectives. Generally, in India, it has been difficult for traditional family businesses to hire professional managers for top positions in their firms because of the lack of an effective labor market that can mobilize human resources. Further, the Indian business culture has been described as, "autocratic, sycophantic, emphasizing personal loyalties rather than professionals" (Manikutty, 2000:289). This is particularly true in emerging economies. Because CEO duality may have a negative impact on innovation, policymakers should consider improving the corporate governance code and further encourage family firms to have an independent and professional CEO.

Our findings also indicate that innovation is impacted by ownership structure and by the lack of supporting institutional frameworks in emerging markets with concentrated family ownership such as India. Thus, policymakers must investigate the impact of institutional underdevelopment on innovation before reforming ownership structure. Moreover, family firms typically have good relationships with the major pillars of the local economy. Our findings may help policymakers to promote an alliance between family firms with research organizations, such as universities, to utilize fundamental scientific knowledge to enhance innovation capabilities in emerging markets.

Limitations

Although this paper tries to minimize the identification problem by employing certain key instruments in appropriate econometric models, it cannot fully overcome the causal effect of family firms on innovation activities. However, as Ornaghi (2009) argues, econometricians cannot always see the correct information to eliminate the endogeneity problem. Our study is no exception. First, there might be omitted variable bias that was difficult to address because of information availability, such as (1) political favors taken by founding families do not appear in the balance sheet but this might affect the performance of family firms, and (2) low innovation performance might be the result of tunneling of capital out of the firm in a business group run by controlling families. Moreover, our results did not take into account the recent economic crisis.

Second, with a sample of Russian (one of the BRIC countries) firms, Judge, Naoumova, and Koutzevol (2003) noted that firm performance decreases when the board of directors is controlled by the CEO of the firm. The study of Villalonga and Amit (2006) also argues that the role of ownership can be examined clearly with information about both ownership and control. Although the enactment of Clause 49 (similar to the Sarbanes-Oxley Act in the US) of Listing Agreements clarifies the composition of the board of directors, we had only limited information of CEO and board structure throughout the survey period in this study. This may bias our findings towards negative association of descendant CEO and innovation.

Third, Indian family firms bring products and technologies to the market so frequently that they do not bother to apply for patents. Therefore, the history of past innovation activities is difficult to obtain to address endogeneity properly and specifically for the study of innovation in emerging markets. Moreover, it may also bias the measurement of innovation productivity if we only consider patented inventions because not all inventions are patented or novel enough to be eligible to be patented.

Concluding Remarks

Despite several limitations, our study has provided important insights into family firms in emerging markets in which the de facto institutional quality might better explain apparent contradictions about the role of family ownership in innovation. We show that using family owners to promote innovation in emerging markets such as India is worth recommending. Family firms, particularly when they are affiliated with business groups, can establish strong research

partnerships with universities, research organizations and other industrial partners in emerging markets. Moreover, they can contribute to regional innovation systems (see Cooke, Gomez Uranga & Etxebarria, 1997) which are conceptualized as an important hub of the innovation network that utilize dynamic relations and interactions with local firms. For instance, Bangalore in India has become the most important IT cluster outside of the OECD countries (Arora & Gambardella, 2004). One of the family firms in the Bangalore IT cluster is Infosys Limited, which successfully provides business consulting, technology and engineering outsourcing services in more than 30 countries. However, the lack of any significant positive association of families with the number of patents in our findings can be alarming for the economy. At first glance, it shows that family firms are generally reluctant to spend money and effort in applying for patents. However, when we further analyze the patent-to-R&D ratio and include it in a dynamic model, we find that family firms care about the transformation of their R&D effort into innovation output. The economic implication is that, even if the family firms engage in less external R&D investment than non-family firms, a proper collaboration and network of R&D can maximize successful innovation output with limited innovation input, which will lead to better innovation productivity for family firms. It shows that fewer registrations of the number of patents cannot simply be interpreted as lower-quality innovation productivity.

Finally, the Indian financial markets have shown impressive growth in recent years as the government has committed to advancing corporate governance reforms, including SEBI's initiative for transparency and good practice in corporate governance. The improvement of the corporate governance landscape in India, along with economic reforms and technological innovations, has helped Indian industry to sustain financial gains and growth. In addition, the transparency and reform in corporate governance in India may attract other equity investors to choose opportunity and potential investments with increased protection against expropriation. Thus, the recent corporate governance measures taken by the Indian government seem to fill existing institutional underdevelopment to attract capital from a variety of external sources. This, indeed, may affect a large number of family firms in India.[6] In addition, Indian family firms may have a strong symbiotic relationship with the elected government and benefit from government protection (Khanna & Palepu, 1997). However, the continued presence of a large number of family firms implies a lack of trust in governmental action. In the post-liberalization period, growing competitive pressures from foreign firms and also imports have stimulated the innovation activities of Indian SMEs, which are also family owned. These SMEs are often provided with funds for technology development, modernization, and technical know-how for innovation activities by the government.

ACKNOWLEDGEMENTS

The authors are grateful to the editor, associate editor and anonymous reviewers for very helpful and constructive suggestions. Suman Lodh gratefully acknowledges Murali Chari and Iftekar Hasan for their support. Jean Chen would like to acknowledge the support from the National Social Science Foundation of China (ID: 10ZD&035), the National Natural Science Foundation of China (ID: 71132001) and the Programme for Changjiang Scholars and Innovative Research Team at Nankai University (PCSIRT) in China. Error remains our own.

NOTES

1. A comprehensive database that contains data on firms' accounts, backgrounds, corporate governance, and share prices since 1990 for a large number of companies. The database includes all firms traded on India's major stock exchanges (and several other smaller exchanges), including public sector enterprises. The database has been used in several papers on Indian firms, such as Khanna and Palepu (2000b), Sarkar and Sarkar (2000), and Bertrand et al. (2002).
2. Some studies establish a minimum control threshold such as 5, 10, or 20 percent for family-owned firms (Faccio & Lang, 2002; La Porta et al., 1999).
3. The conventional Hausman test assumes the asymptotic normality of both fixed- and random-effect estimators, which may not be true in all situations. We also tried to ascertain the significant differences between these two estimators by a bootstrap Hausman test. Using the fixed-effect estimators did not support our findings.
4. Although Griliches and Mairesse (1995) and Blundell and Bond (1998) argue that first-differences are possibly weakly correlated with their lagged levels for production function estimation regressors because many economic variables evolve in a random walk fashion at the micro level. Thus, the GMM estimator may not give consistent results.
5. We have also used the difference GMM as the literature in similar contexts recommends; the suggestion may be made because the lagged levels of the regressors act as weak instruments for the first differenced regressors. Alternatively, "system-GMM", an augmented version of "difference GMM", was used to help obtain efficient estimates for equation (2).
6. We thank one of the reviewers for noting this.

APPENDIX

We consider that the firm follows the condition given below for its long-term innovation activities in the market

$$Y_{it} - Y_{i(t-1)} = \rho\left(Y_{it}^{\tau} - Y_{i(t-1)}\right) + u_{it} \qquad \text{(A1)}$$

where $Y_{i(t-1)}$ is the productivity in $(t-1)$ and Y_{it}^{τ} is the target productivity of the firm in terms of both increased investments in R&D and number of patents, assuming that the firm employs maximum investments of its shareholders in the innovation activities. ρ determines the speed of productivity adjustment coefficient and $0 \leq \rho \leq 1$.

The following situations may happen: If $\rho < 1$, the firm has excess inventions for patenting at time t and it does not want to increase its productivity in the near future, while $\rho = 0$ indicates that the firm believes that its present productivity can place it in a better marketplace in the future, i.e., $Y_{it}^{\tau} = Y_{it}$. However, $\rho = 1$ means that the firm has a plan to increase its productivity because its present R&D activity is not enough to achieve the competitive advantage in the future.

This leads us to an optimal level of firm production that can be represented by the following equation:

$$Y_{it}^{\tau} = \sum_{i,k} \psi_i Z_{k,it} + \varphi_{it} + \sum_{k} D_k + S_t + \vartheta_{it} \tag{A2}$$

where φ_{it} is the vector of the firm's unobservable individual characteristics, D_k is the industry dummies for k industry. S_t indicates the year spell dummies and ϑ_{it} is the iid error term.

Plugging equation (A2) into equation (A1), we obtain

$$Y_{it} - Y_{it-1} = \left(\rho \sum_{i,k} \psi_i Z_{k,it} + \rho\varphi_{it} + \rho \sum_{k} D_k + \rho S_t + \rho\vartheta_{it} - \rho Y_{it-1} \right) + u_{it} \tag{A3}$$

or

$$Y_{it} = (1-\rho) Y_{i(t-1)} + \left(\sum_{i,k} \rho\psi_i Z_{k,it} + \rho\varphi_{it} + \sum_{k} \rho D_k + \rho S_t \right) + \rho\vartheta_{it} + u_{it} \tag{A4}$$

Rearranging we get

$$Y_{it} = \xi Y_{i(t-1)} + \sum_{i,k} \alpha_i Z_{k,it} - n \sum_{i,k} \alpha_i Z_{k,i(t-1)} + \mu_{it} - n\mu_{i(t-1)} + \delta_k (1-n) + d_t - n d_{t-1} + \varepsilon_{it} \tag{A5}$$

For unobserved individual factors that are time-variant, e.g., the technological knowledge of the scientists in R&D, we allowed $\mu_{it} = n\mu_{i(t-1)} + e_{it}$, to be first order autoregressive, $|n| < 1$.

After simplifying and allowing Y_{it} variable for p years of lag,

$$Y_{it} = \sum_{p} \xi_p Y_{i(t-p)} + \sum_{i,k} \alpha_i Z_{k,it} + \mu_{it} + \delta_k + d_t + \varepsilon_{it}, \quad p > 0 \tag{A6}$$

where

$$\xi = (1-\rho),\ \alpha_i = \rho\psi_i,\ \mu_{it} = \rho\varphi_{it},\ \delta_k = \sum_{k} \rho D_k,\ d_t = \rho S_t,\quad \varepsilon_{it} = (\rho\vartheta_{it} + u_{it})$$

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