Product Innovations in Emerging Economies:

The Role of Foreign Knowledge Access Channels and Internal Efforts in Chinese Firms

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ABSTRACT

In this paper we theoretically and empirically investigate factors that contribute to product innovation by firms in emerging markets. Combining the innovation literature with the latecomer literature on "catch-up" strategies of firms in newly industrialized economies, we posit that access to foreign knowledge is essential for fostering product innovation. In particular, we investigate how innovation clusters formed by inward FDI in an emerging market and export activities of a firm are effective channels for acquiring foreign knowledge. We also suggest that firms that invest in R&D and marketing activities benefit further from access to foreign knowledge due to increased absorptive capacity. Empirically, we employ information on over 160,000 manufacturing firms in China in 2005-2006. We find strong empirical support for our theoretical framework and conclude by discussing the implications for both theory and managerial practice.

Key words: product innovation, clusters, learning by exporting, R&D, marketing, China
Running head: Product Innovations in Emerging Economies

INTRODUCTION

Innovative activity is a critical determinant of competitive advantage (Porter, 1990). Since most innovative activity occurs, or has occurred, in developed countries it is not surprising that most of our understanding of the determinants and effects of innovative activity comes from studies of firms in those markets (e.g., Cohen & Levinthal, 1990; Dosi, 1988). Although firms in emerging economies are commonly regarded as laggards in innovations, especially in cutting-edge innovations (Altenburg, Schmitz & Stamm, 2008), recent evidence, derived mainly from case studies, suggests that firms in emerging markets do in fact innovate (Lu, 2000). Computing companies in China and pharmaceutical companies in India are able to develop new products either by adding significant value to imported foreign products or technologies or by developing new products to satisfy specific domestic demands (*Business Week,* 2008; Lu, 2000). These companies are not only innovation leaders in their domestic markets, but they are increasingly able to compete in international markets (Altenburg et al., 2008).

Despite these developments, theoretical discussion and empirical tests related to innovation by firms in emerging economies have been limited (Horng & Chen, 2008; Jefferson, Bai, Guan, & Yu, 2007; White, Hoskisson, Yiu, & Bruton, 2008). In this paper we aim to advance this literature by examining in depth the determinants of product innovation among firms in one important emerging-market, China. In particular, this study investigates whether and how the current innovation framework, largely based on innovative behavior of firms in developed economies, should be modified in an emerging-market context, as well as how firms in emerging markets, as latecomers to the world market, can overcome their latecomer status in developing innovative capabilities.

The extant innovation literature uses the innovation experiences of firms in developed

economies to suggest that knowledge is the key to a company's innovation (Grant, 1996), and companies can generate the requisite knowledge for innovation internally through in-house R&D and marketing, and externally through channels such as strategic alliances and acquisitions (e.g., Ahuja, 2000; Atuahene-Gima & Ko, 2001; Chandy, Hopstaken, Narasimhan, & Prabhu, 2006; Cohen & Levinthal, 1990; Danneels, 2002; Griffin & Hauser 1993). Adapting this framework to the emerging-market context, we first recognize that firms in emerging markets, unlike their counterparts in developed economies, typically do not have the internal knowledge or capabilities to engage in extensive R&D activities, and we suggest that access to external, advanced foreign knowledge is therefore crucial for firms in emerging markets to improve their innovative capabilities. To reach this conclusion, we draw mainly on the latecomer literature that suggests that firms in emerging markets, as latecomers, typically face two types of disadvantages that limit innovation. First, they do not have access to a stock of advanced technological knowledge (a supply factor for innovation) and second, they lack access to a domestic consumer base with sophisticated needs (a demand factor for innovation) (Hobday, 1995; Kim, 1997; Mathews, 2002; Mathews & Cho, 1999). To overcome these disadvantages, we posit that firms in emerging markets require access to superior foreign technology and customer knowledge.

In particular we investigate two channels by which firms in emerging markets can access such foreign expertise: exporting activities, and innovation clusters formed by inward foreign direct investments (FDI) in an emerging market. We extend the existing literature to argue that *both* channels provide opportunities for firms in emerging markets to be in direct contact with foreign knowledge holders, which facilitates knowledge transfer (Audretsch & Feldman, 1996; Bernard & Jensen, 1999). We focus on export and innovation clusters of inward FDI as channels of foreign knowledge spillovers for two reasons. First, some emerging markets, in particular

China, have attracted large amounts of FDI, and have encouraged exporting activities to exploit their cost advantages. While there seems little doubt that export and inward FDI have speeded up the economic development of emerging markets, there is little systematic evidence on how export and inward FDI operate as knowledge spillover channels and affect innovation by firms in emerging markets (for a review of FDI spillovers see Meyer & Sinani, forthcoming). Second, the extant literature, in investigating external knowledge sources for innovation, mainly focuses on the impact of strategic alliances and acquisitions (Ahuja, 2000; Hagedoorn & Schakenraad, 1994; Lyles & Salk, 1996; Nicholls-Nixon & Woo, 2003). Exports and inward FDI, despite their potentially important role in generating knowledge spillovers, receive far less attention in the innovation literature (Salomon & Shaver, 2005).

In our theoretical framework we also emphasize the important moderating effect of internal knowledge creation efforts in enhancing firms' benefits from access to foreign knowledge. Although firms in emerging markets do not typically possess abundant resources for R&D or marketing activities, we suggest that these activities are nonetheless crucial for improving innovative capabilities of firms because they enhance firms' absorptive capacity--that is, their ability absorb foreign knowledge and adapt it to satisfy local conditions (Cohen & Levinthal, 1990). We therefore argue that such internal efforts are critical moderating factors that strengthen the positive impact of foreign knowledge access channels (that is, export activities and innovation clusters of inward FDI) on firm innovation.

To test our theoretical framework, we utilize information on more than 160,000 Chinese firms in the 2005 and 2006 editions of Annual Census of Industrial Enterprises, complied by the National Bureau of Statistics of China. To our best knowledge, this is one of the first studies to use a large dataset to empirically test the determinants of firm innovation in emerging markets;

previous studies have relied mainly on case studies (Hobday, 1995; Kim, 1997; Mathews, 2002). We employ Tobit regression techniques and conduct several robustness tests, and report results largely consistent with our theoretical framework, confirmining that latecomer firms can in fact benefit from access to foreign knowledge.

The study proceeds as follows. In the next section, we present the theory and hypotheses. This is followed by a discussion of our empirical strategies and the estimation results. Finally, we discuss the implications of our study for the literature and for firms and governments in emerging markets.

THEORETICAL BACKGROUND AND HYPOTHESES

The knowledge-based view of the firm suggests that knowledge is a key competitive asset and is fundamental for improving product innovation (Grant, 1996). Knowledge and its growth within the firm depend on both internal and external learning (Kogut & Zander, 1992). Drawing upon the experience of firms in developed economies, the existing innovation literature explores how firms perform and manage marketing, manufacturing, and R&D activities so as to generate and integrate internal knowledge for innovation (Atuahene-Gima & Ko, 2001; Brown & Eisenhardt, 1995; Chandy et al., 2006; Danneels, 2002; Dougherty, 2001; Griffin & Hauser, 1993). In addition to internal knowledge creation, the extant literature also suggests that firms can acquire knowledge from external sources by engaging in external business development activities in the forms of strategic alliances or acquisitions, or by locating in innovation clusters, and prior research has documented the positive relationships between external knowledge access channels and firm innovativeness (Ahuja, 2000; Ahuja & Katila, 2001; Almeida & Kogut, 1999; Globerman, Shapiro, & Vining, 2005; Hagedoorn & Schakenraad, 1994; Nicholls-Nixon & Woo,

2003).

Since the above studies are mainly conducted in developed markets, applying them to the emerging-market context warrants modifications. Unlike their counterparts in developed economies, firms in emerging markets are often called ‘latecomers’ because they are late to enter their targeted industries relative to successful multinational enterprises and they are far behind the incumbents in terms of technological capabilities (Mathews, 2002; Mathews & Cho, 1999). A latecomer firm faces two types of disadvantages in terms of technological development (Hobday, 1995; Kim, 1997). First, from the technology supply side, a latecomer firm operates in isolation from the world centers of science and innovation, and it typically has limited human and technological resources for innovation. Second, from the consumer demand side, a latecomer firm is dislocated from mainstream, sophisticated international markets, which limits the firm’s exposure to advanced market knowledge for innovation.

These challenges from both the supply and demand sides of innovation make it less feasible or even desirable for emerging-market firms to expend substantial internal efforts for innovation (relative to developed-country firms). However, firms in emerging markets may find it possible to access and integrate advanced foreign technology and marketing knowledge in order to overcome the innovation hurdles associated with their latecomer status. Several studies on technology catch-up by firms in newly industrialized economies (e.g., South Korea, Singapore, and Taiwan) help to illustrate this point; they find that, unlike western multinational firms which focus on internal development of cutting-edge technologies, latecomer firms upgrade their technological capabilities through constant acquisition, assimilation, and improvement of imported or licensed foreign technologies or products (Cho, Kim, & Rhee, 1998; Choung, Hwang, Choi, & Rim, 2000; Hobday, 1995; Kim, 1997; Mathews, 2002; Mathews &

Choi, 1998).

As our central proposition is that access to foreign knowledge is indispensible for firm innovation in emerging markets, a natural question is whether and how firms in emerging markets can access and acquire foreign knowledge. The extant literature on knowledge transfer and organizational learning in less developed economies provides an extensive discussion on the role of strategic alliances in facilitating knowledge acquisition and capability building of local firms (Cho et al, 1998; Hobday, 1995; Lyles & Salk, 1996). What is much less discussed is how export activities and innovation clusters formed by inward FDI contribute to knowledge transfer and affect innovation of firms in emerging markets. We investigate both of these channels and argue below that both provide additional and substantial opportunities for firms in emerging markets to be in direct contact with foreign knowledge holders, and such active involvement with knowledge holders is a critical determinant of tacit knowledge transfer (Grant, 1996; Kogut & Zander, 1992). We further suggest that internal R&D and marketing efforts, although not extensively conducted by many emerging-market firms, are important moderating factors; internal efforts can accelerate firms' absorption and adaptation of foreign knowledge to local innovation and thus enhance their benefits from accessing foreign knowledge.

Foreign Knowledge Access Channels

Innovation clusters refer to geographic concentrations of highly innovative, interconnected companies and institutions in a particular field (Porter, 1998). The idea that location is an important source of competitive advantage for firms has been well recognized in the innovation literature (Almeida & Kogut, 1999; Globerman et al., 2005; Porter, 1990; Zhou & Li, 2008). The underlying mechanism is that by co-locating their production facilitates, firms can benefit from

proximate supplies, heightened demand, and more importantly, spillovers of valuable knowledge (Almeida & Kogut, 1999). The literature has provided strong evidence to support the idea that knowledge is often essentially localized, and that knowledge spillover is therefore more likely to occur within a specific location (Audretsch & Feldman, 1996; Jaffe, Trajtenberg, & Henderson, 1993; Globerman et al., 2005). In essence, geographic proximity reduces transaction costs and increases the frequency of personal contacts that build social relations between companies in the same location, thereby facilitating the flow of knowledge (Saxenian, 1991).

The above studies suggest that in locations with concentrated foreign innovative activities, domestic firms can benefit substantially from knowledge spillovers from foreign neighbors including suppliers, customers, and competitors. Specifically, domestic firms can acquire knowledge, particularly tacit knowledge, through hiring talented employees from foreign firms; by developing valuable business networks (e.g., supplier-customer networks) with foreign firms; and by accesssing social networks of foreign employees in the same location. Existing empirical studies find that the mobility of engineers and inventors is high in innovation clusters (Almeida & Kogut, 1999), and hiring experienced people plays a critical role in allowing companies to overcome latecomer disadvantages (Cho et al., 1998) both because of a one-time transfer of knowledge, but also a transfer of capabilities, allowing further knowledge building (Kim, 1997). We thus expect domestic firms to exhibit stronger innovative capabilities in areas with concentrated foreign innovations. Stated formally,

H1. In an emerging market, innovation clusters of foreign firms will have a positive effect on product innovation by domestic firms in the clusters.

Exporting activities are another important foreign knowledge access channel. The

literature suggests that international trade facilitates bilateral exchange of knowledge across borders and exposes low-productivity countries to knowledge from their well-endowed destination countries (Grossman & Helpman, 1993). Existing empirical studies have mainly focused on how learning-by-exporting affects the productivity of exporters but have seldom investigated how exporting activities affect innovative capabilities of exporters (Salomon & Shaver, 2005). In this study, we suggest that learning by exporting can contribute to product innovation by exporters in emerging markets.

Foreign importers are often willing to transfer knowledge extensively in order to ensure the quality and performance of imported products. For instance, they often provide exporters with information and feeback on product design, production techniques, quality and cost control, foreign consumer needs, and competing products (Evenson & Westphal, 1995; Hobday, 1995; Salomon & Shaver, 2005). Such transfer of technological and marketing knowledge from foreign importers can help exporters in emerging economies overcome the major barrier to innovation facing latecomers, that is, the isolation from world centers of science and innovation, and the lack of exposure to advanced consumer knowledge in international markets (Hobday, 1995). Moreover, during the process of absorbing foreign knowledge and tailoring products to meet the needs of foreign consumers, exporters also develop capabilities in assimilating foreign products and even designing new products (Hobday, 1995).

The experiences of firms in East Asian economies provide support for the above arguments. Hobday (1995) studies the technological development of electronics industries in the Four Little Dragons (South Korea, Taiwan, Hong Kong, and Singapore), and finds that learning by exporting contributes considerably to the technical progress of firms in these economies. Many successful latecomer firms, such as Samsung and Acer, originally worked as

subcontractors or original equipment manufacturers (OEMs) for foreign buyers during the 1980s and 1990s. Because foreign buyers train managers, engineers, and technicians and also provide advice on production, financing, and management, subcontracting and OEM act as training schools for firms in newly industrialized economies, enabling them to master the manufacturing and design technology of foreign companies (Hobday, 1995). The knowledge accumulated during this stage plays a critical role in the transformation of firms from exporters to companies with innovative capabilities (Hobday, 1995; Mathews, 2002). There is also anecdotal evidence from Chinese firms to support this argument. Companies such as Galanz (microwaves), Lenovo (computers), Haier (household appliances), and TCL (televisions), all started as contract manufacturers for different international brands. Using the knowledge transferred from foreign importers, these companies improved their manufacturing skills and developed new product design capabilities (Arrunada & Vazquez, 2006; Child & Rodrigues, 2005). In summary, we expect that firms engaged in exporting activities will exhibit stronger innovative capabilities. Formally, we propose:

H2: In an emerging market, a firm's export activities will have a positive effect on product innovation by the firm.

Internal Knowledge Creation Efforts

The above arguments suggest that firms in emerging markets can improve their innovative potential by co-locating in regions populated by large numbers of foreign firms, or by engaging in export activities. We further argue that the extent to which a firm can benefit from foreign knowledge access channels depends on its internal efforts (e.g., R&D and marketing activities) that ultimately determine the firm's ability to absorb foreign knowledge and apply it to satisfy

local needs. Firms in emerging economies cannot simply introduce new technologies or products developed by foreign firms into their domestic markets without modifications. Indeed, R&D efforts are needed to modify foreign technology or products to suit local consumer needs or government requirements (Bell & Pavitt, 1993; Lall, 1987, 1992; Lu, 2000). Good examples to illustrate this point can be found in Lu (2000) who carries out field research of four Chinese computer companies: Stone, Legend, Founder, and Great Wall, and finds that the success of these companies relies on their R&D efforts that add new technological functions, integrating the Chinese language to imported products, and tailoring them to local specifications.[1]

R&D efforts not only contribute directly to one-time modification of foreign products, but also enhance absorptive capacity, that is, the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1989, 1990). This is the so-called dual-role of R&D activities (Cohen & Levinthal, 1989). With an appropriate level of absorptive capacity, firms become more capable of absorbing, assimilating, and adapting external knowledge embedded in the foreign knowledge access channels (innovation clusters of inward FDI and export activities) and thus become more innovative. Kim (1997), in examining the successful technological improvement of Korean firms in automobile, electronics, and semiconductor industries, suggests that in-house R&D efforts are indispensible for improving these firms' ability to absorb external knowledge and for speeding up the technological catch-up process. By the same reasoning, we posit that as R&D efforts boost firms' absorptive capacity, they will positively moderate the relationships specified in H1 and H2, that is, they will enlarge the positive effects of export activities and foreign innovation clusters on innovative activity by emerging-market firms. Formally, we propose:

H3a. The stronger a firm's R&D efforts, the stronger the positive effect of innovation

clusters of inward FDI on its product innovation.

H3b. The stronger a firm's R&D efforts, the stronger the positive effect of exporting activities on its product innovation.

Similar to the role of R&D efforts, marketing efforts will also increase a firm's ability to absorb external knowledge and modify it to local use. Firms engaged in extensive marketing will understand what kinds of external knowledge, products, or technologies are appropriate for the local markets as well as what modifications are needed to satisfy local consumer demands (Han, Kim, & Srivastava, 1998; Lukas & Ferrell, 2000). Marketing efforts are particularly important in understanding local consumer needs in emerging markets. First, since emerging markets typically lack well-established and reliable market research intermediaries, firms cannot purchase readily available market information from market research companies, and instead need to expend substantial marketing efforts to gather credible market information (Khanna & Palepu, 1997). For instance, Zong Qinghou, the former general manager of Wahaha Group (soft drink producer), commented that "market research reports in China are not reliable. You pay the market research firms large amount of money and you don't know where the money was spent. Our own marketing people are our market research staff. ….We make decisions based on their understanding of the market" (Dawar & Dai, 2003).

Second, the nature of consumer demand in emerging markets is more complex than that in developed market economies, and this often requires different types of product innovations. Thus, Khanna and Palepu (2006) divide product markets in emerging markets into four distinct tiers: a *global* customer segment that demands products of global quality and with global features and is willing to pay global prices for them; a "*glocal*" segment that demands products of global

quality but with local features at less-than-global prices; a *local* segment that wants local products with local features at local prices; and a *bottom* segment that can afford to buy only the most inexpensive products. Although the global consumer segment desires product offerings with the same quality and attributes that goods in developed countries have, the majority of the consumers in emerging markets (glocal, local, and bottom consumers) have needs that are different from those in developed countries. It follows that firms that conduct marketing research to understand different tiers of demands are better capable of adapting foreign products and technologies to satisfy different market segments. In other words, with more marketing efforts and market knowledge, firms will be more capable of utilizing foreign knowledge embedded in innovation clusters of inward FDI and export activities to become more innovative. We propose the following hypotheses to capture the moderating effect of marketing efforts in strengthening the relationships specified in H1 and H2.

H4a. The stronger a firm's marketing efforts, the stronger the positive effect of innovation clusters of inward FDI on its product innovation.

H4b. The stronger a firm's marketing efforts, the stronger the positive effect of exporting activities on its product innovation.

METHOD

Data Description

To test the hypotheses, we constructed a sample of 160,702 Chinese firms by utilizing the 2005 and 2006 editions of *Annual Census of Industrial Enterprises*. The Census data are assembled by the National Bureau of Statistics of China (NBSC), which has endeavored to maintain high levels of consistency in data collection across time, industries, and regions (Zhou & Li, 2008).

The Census data includes firms in industrial sectors with an assessed sales capacity of no less than 5 million Chinese Yuan per year. It contains detailed information about a company's operational profile, such as total output value, new product value, and export value. We rely mainly on the Census data in 2005 and 2006 because some of the most important measures for our study such as R&D expenditures are available only since 2005. Chinese firms in our data sample are those firms with at least 95% Chinese ownership.

Our sample includes all manufacturing firms in the census (with two-digit industry code from 13 to 42) with complete information for analysis except those in two industries: food processing and petroleum refining and coking. These are excluded because firms in these two industries show extremely low levels of product innovation which appear to be industry-determined.[2] Thus, the industries included in the sample are: food production; beverage production; tobacco processing; textile industry; garments and other fiber products; leather, fur, down and related products; timber processing, bamboo, cane, palm fiber and straw products; furniture manufacturing; paper making and paper products; printing and record medium reproduction; cultural, educational and sports goods; raw chemical materials and chemical products; medical and pharmaceutical products; chemical fiber; rubber products; plastic products; nonmetal mineral products; smelting and pressing of ferrous metals; smelting and pressing of nonferrous metals; metal products; ordinary machinery; special purpose equipment; transport equipment; electric equipment and machinery; electronic and telecommunications; instruments, meters, cultural and clerical machinery.

Variables and Measures

Dependent variable

Following previous research (Zhou & Li, 2008), we constructed *product innovation* as

our dependent variable, which is the ratio of new product value to total output value of a firm.[3] According to NBSC, new products are defined in the census data as those new to the Chinese market, which either (1) adopt completely new scientific principles, technologies, or designs, or (2) are substantially improved in comparison with existing products in terms of performance and functionality, through significant changes in structure, materials, design, or manufacturing processes (China Statistical Yearbook, 2006: 292). Note that a firm's new products are subject to local government's certification that is generally valid for up to three years (China Statistical Yearbook, 2006: 292). We adopted a ratio measure for product innovation, as opposed to the absolute market value of new products, because total output value can help control for the effects of different economic scales across industries (Zhou & Li, 2008). In addition, a recent McKinsey survey (McKinsey, 2008) suggests that product innovations, measured in this way, is the indicator most used by companies to track innovative performance.

Explanatory variables

The first explanatory variable is *regional foreign innovation*, which is meant to capture clustering of foreign innovative activities. Following Dunning and Narula (1995), we measured in which locations new products produced by foreign-owned firms in an industry are concentrated.[4] Formally, for each year we construct

$$Regional\ foreign\ innovation_{kl} = \frac{foreign\ new\ product_{kl}}{\sum_l foreign\ new\ product_{kl}},$$

where $foreign\ new\ product_{kl}$ denotes the total new product value by foreign firms of industry k in a metropolitan city and its surrounding area l (defined by the first four digits of postal codes).[5] Hence, for every firm with the same industry-city combination, the numerical value of the regional innovation measure would be identical, and it varies across firms in different industries or in different cities. We also developed an alternative measure for regional clusters, as discussed

in the robustness check section.

To capture firms' export activities, we used *export intensity* calculated as the ratio of a firm's export value to its total output value normalized by the same ratio for the industry to which the firm belongs.[6] Specifically, for each year

$$Export\ intensity_i = \frac{exp_i / output_i}{\sum_{j=1}^{n_k} exp_{jk} / \sum_{j=1}^{n_k} output_{jk}},$$

where *exp* is the export value and *output* is the total output value of a firm. The subscripts *i* and *j* are firm indices, and n_k is the total number of firms in industry *k* (according to three-digit industry classification codes). The industry normalization is meant to control for the potential differences in export activities across industries. Unlike previous studies that mainly employ export volume to capture export activities (Clerides, Lach, & Tybout, 1998; Salomon & Shaver, 2005), we use export intensity because our dependent variable, product innovation, is also a ratio measure.

The explanatory variables also include *R&D intensity* and *marketing intensity*, which respectively measure a firm's R&D and marketing efforts. Following Salomon and Shaver (2005) and similar to the construction of export intensity, these variables are defined for each year as follows.

$$R\&D\ intensity_i = \frac{R\&D_i / revenue_i}{\sum_{j=1}^{n_k} R\&D_{jk} / \sum_{j=1}^{n_k} revenue_{jk}},$$

$$Marketing\ intensity_i = \frac{Selling\ expense_i / revenue_i}{\sum_{j=1}^{n_k} Selling\ expense_{jk} / \sum_{j=1}^{n_k} revenue_{jk}},$$

where *R&D* and *Selling expense* indicate a firm's expenditures on R&D and sales-related activities, and *revenue* is the firm's total revenue. Selling expenses include various costs that

firms incur on marketing research and promotional activities. The subscripts *i* and *j* are firm indices, and n_k is the total number of firms in industry *k*. In the above definitions, the ratios of R&D and selling expense to the revenue of firm *i* are normalized by the same ratios computed for the industry to which firm *i* belongs. The industry normalization controls for potential differences in the nature of products and in the innovation process across industries.

For the three explanatory variables described above (export intensity, R&D intensity, and marketing intensity), we used their one-year lagged values from the 2005 data file because the lagged values better capture the learning effects of these activities (Clerides et al., 1998; Salomon & Shaver, 2005). The use of the lagged values means that in effect we focus on explaining product innovations of Chinese firms in 2006. Accordingly, the information from the 2006 Census is used for the rest of the covariants in the regression analysis.

Control variables

We first controlled for three firm-level factors. We measured *state control* as a dummy variable, which is equal to 1 if state equity share is higher than the share of any other types of ownership, which include corporate, individual, collective, and foreign. While firms with state control may possess more financial and labor resources for innovations, these firms may also have lower organizational efficiency for innovative activities (Peng & Heath, 1996; White et al., 2008; Zhou & Li, 2008), so the sign of state control is uncertain.

Another firm-level control variable is *size*, which is the logarithm of total assets of a firm. Firm size may be a proxy for economies of scale and thus have a positive impact on a firm's product innovations. We also included *age*, measured as 2006 minus the opening year of the firm. The effect of the age variable on product innovations is ambiguous because on the one hand, a longer history of operation may suggest a higher level of efficiency, but on the other hand, older

firms are more likely to inherit the legacies of the central-planning feature of the pre-reform Chinese economy.

We also used three variables to control for the effect of industry structure. First, we used firm-level information for local market sales to construct a standard Herfindahl measure for *market concentration*. For a given firm *i* in industry *k*,

$$Market\ concentration_{ik} = \sum_{i=1}^{n_k} \left(sales_{ik} / \sum_{j=1}^{n_k} sales_{jk} \right)^2.$$

In highly concentrated industries, firms may have more resources for product innovations but they may also have less competitive pressure for conducting innovative activities, so the effect of market concentration is ambiguous.

The second industry control is *industry innovation*, which is measured as the ratio of new product value to total output value in an industry. We expect industry innovation to have a positive effect on product innovations. The third industry-level control is *foreign presence*, which is constructed as foreign equity in an industry divided by the total equity in the industry (Zhou & Li, 2008). We expect foreign firms' presence to benefit product innovations of local firms through direct or indirect knowledge spillovers that are not related to clustering of foreign firms, or through the competitive incentives provided by strong foreign competitors. Note that the calculations of the above three industry variables are based on information on *all* firms including foreign firms in China. Also, we include a full set of industry dummy variables, according to two-digit industry codes, to control for other types of industry heterogeneity such as different government policies towards industries. Finally we include a full set of province dummy variables to control for other possible locational effects not captured by regional foreign innovation.

Estimation Issues

A notable feature of the data is that a large proportion (87.3%) of firms in the sample report no new products. Firms' decisions on product innovation can be modeled as follows. Firms maximize profits by choosing the optimal level of new products, subject to the constraint that such choice has to be non-negative. Thus our dependent variable can only be partially observed for firms whose optimal choice of new products takes values other than the corner solution of zero.[7] Denote the unconstrained optimal new product ratio for firm *i* by *Product innovation**, which has the following functional form,

$$Product\ innovation_i^* = \mathbf{x}_i'\beta + \varepsilon_i,$$

where $\mathbf{x}_i$ is a vector of covariants and ε_i is the error term. *Product innovation** can be fully observed only when it is greater than zero. Hence, what we actually have in the sample is *Product innovation* such that

$$Product\ innovation_i = \begin{cases} product\ innovation_i^* & \text{if } product\ innovation_i^* > 0, \\ 0 & \text{if } product\ innovation_i^* \le 0. \end{cases}$$

To accommodate the censored nature of the dependent variable, we use the Tobit method to estimate the model (Tobin, 1958). Essentially, the Tobit model takes into account the fact that the underlying distribution of the error term of the model is truncated. The model is estimated by maximum likelihood method, which yields consistent estimators for the model parameters.

RESULTS

Descriptive Statistics

Table 1 presents the correlation matrix and descriptive statistics for the key variables. The average new product ratio (product innovation) is 4% among Chinese firms in the selected industries.[8] The average age of firms is about 9.7 years. With the privatization of the Chinese

state-owned sectors, only 5% of the firms in our sample were still controlled by the state in 2006. Note that export intensity, R&D intensity, and marketing intensity reported in Table 1 were all normalized by the corresponding intensity values at the industry level. The un-normalized measures of export intensity, R&D intensity, and marketing intensity have means at 0.110, 0.002, and 0.030, respectively, which to some extent suggest that export provides a more feasible means to generate knowledge and innovation than internal efforts. The high standard deviations in R&D intensity suggest that there are strong within-industry variations in R&D activities. On average, foreign investment accounts for about 35% of total equity, suggesting the strong presence of foreign companies in the selected industries.

INSERT TABLE 1 ABOUT HERE

Regression Results

Table 2 summarizes the estimation results of the main effects of the independent variables based on the Tobit method. As a benchmark, we first included control variables only in Model 1. We then added the four independent variables sequentially in Models 2-7. The results show that regional foreign innovation, export intensity, R&D intensity and marketing intensity all have significant, positive impacts on firms' product innovations. These results are robust to changes in model specification, as the signs and magnitude of the parameter estimates remain largely the same when more variables were added sequentially to the model. Thus, H1 and H2 are strongly supported by the data, that is, innovation clusters of inward FDI and exports contribute to product innovation by Chinese firms. In addition, the results show that internal knowledge creation efforts in R&D and marketing contribute also benefit firms' product innovation.

INSERT TABLE 2 ABOUT HERE

To better understand the results, we compute the elasticities associated with export intensity, R&D intensity and marketing intensity.[9] Given the censored nature of the dependent variable, the elasticities are computed based on the decomposition of the marginal effects in the Tobit model as suggested by McDonald and Moffitt (1980). For a 1% increase in export intensity, the probability that a firm will have positive product innovation increases by about 0.159%. The comparable elasticities for R&D intensity and marketing intensity are respectively 0.010% and 0.028%. Additionally, for a 1% increase in export intensity, the increase in a firm's new product ratio, conditional on it being positive, is about 0.037%. The comparable elasticities for R&D intensity and marketing intensity are respectively 0.002% and 0.007%. These results suggest that among these factors, exporting activities have the strongest impact on Chinese firms' product innovation.

To test H3a and H3b, we augment the model with a full set of explanatory variables (Model 7) by including interaction terms between R&D efforts and the variables indicating foreign knowledge access channels (regional foreign innovation and export).[10] The results are summarized in Table 3. Models 8, 9, and 10 show that the interactions between R&D intensity and regional innovation (or export intensity) have significant and positive effects on product innovation by Chinese firms. These results show strong support for H3a and H3b, and suggest that R&D activities increase firms' ability to absorb knowledge from innovation clusters of inward FDI and export activities.

INSERT TABLE 3 ABOUT HERE

Similarly, we test H4a and H4b by including the interaction terms between marketing efforts and the two variables indicating foreign knowledge access channels. The estimates are reported in Table 4. Models 11, 12, and 13 indicate that the joint impact of marketing intensity and regional foreign innovation (or export intensity) on product innovation has a positive sign but is not statistically significant. Therefore, H4a and H4b are not supported by the sample. As we will discuss in more detail below, this result could depend on the sample composition.

INSERT TABLE 4 ABOUT HERE

Finally, some results regarding the control variables are worth mentioning. First, state control has no effect on product innovations in the sample, which suggests that although state-controlled firms may have more resources for innovations, they may be less efficient in producing them. At the industry level, foreign presence has a positive effect on product innovation by Chinese firms, which shows support for the existence of non-locational knowledge spillovers and/or competitive effects created by foreign direct investment. The results also show that innovative activities at the industry level have a positive impact on firm-level innovation. Finally, we find that market concentration has a negative effect on product innovation, which may indicate that in a highly concentrated market, firms face less competition in product markets and thus have fewer incentives to develop new products. Together with the results for the impact of foreign presence, these results suggest that a competitive market environment with both local and foreign firms is critical for product innovations of firms in China.

Robustness Check

To check for the overall robustness of the empirical results, we implemented the following procedures. First, instead of employing one-year lagged values for export intensity, we also tested three-year lagged values by using the 2003 Census data.[11] The results remain qualitatively the same. Second, we adopted an alternative measure for regional foreign innovation. The new measure is constructed as the ratio between the new product value by foreign firms of a certain industry in a region and the total output value in that industry-region combination. We found that our results are not sensitive to the changed measure. Third, we used an alternative measure for marketing intensity, which is constructed in a similar fashion as the original one but based on selling expenses minus advertising expenditures. The results remain qualitatively the same. Finally, we estimated the same set of models on various subsamples and the results are very similar to the results that are based on the full sample. One interesting exception is that when we restrict the sample to high technology industries (as defined by NBSC),[12] the interaction effects between marketing intensity and regional foreign innovation (or exports) become positive and statistically significant. This result suggests that marketing activities play a more important role in enhancing firms' ability to absorb external knowledge in industries that produce more sophisticated products.

DISCUSSION

In this study, we have examined factors that contribute to product innovation by Chinese firms. We contribute to the extant innovation literature that has primarily focused on innovation of firms in the context of developed economies. We have drawn upon the latecomer literature (Cho et al., 1998; Hobday, 1995; Kim, 1997; Lu, 2000; Mathews, 2002) to suggest that access to foreign knowledge is critical for improving firm innovation in emerging markets. Specifically,

we have proposed a framework in which innovation clusters of inward FDI and exporting activities, as foreign knowledge access channels, foster the innovative capabilities of firms in emerging markets. We have also suggested that R&D and marketing efforts, by affecting firms' ability to absorb foreign knowledge, enhance the positive effects of foreign knowledge access channels on firm innovation. Empirically, we have utilized the most recent information on over 160,000 Chinese firms in manufacturing industries in 2005 and 2006 to find strong support for our theoretical framework.

Our study is among the first empirical studies to examine the impact of clusters formed by inward FDI on product innovation by firms in an emerging market. Although the Chinese government has long promoted the establishment of innovation clusters, such as science parks and incubators, for advancing innovativeness of domestic firms, the effectiveness of such a policy has not been fully explored. Different from existing studies that mainly use aggregate industry or regional data to analyze the impact of clusters on industry productivity in China (Fan & Scott, 2003), our study is based on firm-level innovation data. Our findings suggest that in cities with concentrated foreign innovative activities, domestic firms will benefit substantially from foreign knowledge spillovers. These results indicate that clusters of foreign firms represent important channels for knowledge acquisition in emerging economies.

Our study is also among the first studies to examine how export activities affect product innovations by firms in emerging markets. Our findings suggest that export activities in previous years contribute to the current product innovation of firms, a result which is robust in terms of the lag structure in exporting activity. The result supports the idea of learning by exporting, resulting from the transfer by foreign importers of advanced market and technological knowledge in order to ensure product quality and performance. Thus, exporting provides

exporters with access to foreign knowledge, which improves their ability to design and develop new products. As the literature has mainly focused on how learning by exporting contributes to firm productivity (e.g., Bernard & Jensen, 1999), our results add a new perspective for understanding the benefits of export activities for firms by focusing directly on how exporting contributes to firms' ability to develop new products.

Our results also suggest that R&D efforts, although not extensively conducted by firms in emerging markets, play an important role in affecting product innovation. The importance of R&D in determining innovations has been well recognized in developed economies as many studies have documented its positive impact on innovation (e.g., Cohen & Levinthal, 1989, 1990). The importance of R&D in emerging economies, however, has not received much attention among mainstream economists who tend to assume that openness and easy access to foreign technology sources are all that matter to the performance of firms in emerging markets (Chudnovsky, Lopez, & Pupato, 2006). Our results indicate the important dual role of R&D activities in emerging markets. That is, R&D efforts not only have a direct impact on product innovation by Chinese firms but they also enhance absorptive capacity, which helps firms to recognize, absorb, and adapt useful foreign knowledge embedded in external channels, such as innovation clusters and exporting. These effects magnify the positive impact of foreign knowledge channels on product innovation. Similarly, our results also suggest the dual role of marketing efforts in improving firm innovativeness, although the impact might be less robust. Marketing efforts do have a positive direct impact on firm innovation, but the degree to which they enhance firms' ability to absorb and adapt foreign technologies or products to develop local innovations may be restricted to high technology industries.

Our study has important implications for government policy and firm strategy. The

implication for governments in emerging economies is that they should support or continue to support the development of innovation clusters, and they should also continue to encourage export activities. The implication for firms is that they should pay attention to locational choice for their businesses and establish subsidiaries in foreign innovation clusters in order to tap into the available pools of knowledge and talents. Also, firms should consider exporting as a valuable and effective learning tool for upgrading their innovative capabilities. Last, firms in emerging markets should be aware of the dual-role of R&D and marketing activities, view them as vital for improving their innovative capabilities, and actively engage in such activities for speeding up knowledge acquisition and capability building. Our study also challenges the open innovation model often used by firms in developing countries. In this model, firms seek technology from external sources while paying little attention to internal efforts for their innovation needs. Our results suggest that a complete reliance on open sources is not optimal for innovation; indeed, firms need to enhance their internal R&D capability and absorptive capacity in order to accelerate the development of innovative capabilities.

Future research could enrich our theoretical framework and extend our empirical analysis in a number of ways. First, to our knowledge, the impact of export on innovation has not been discussed in the context of developed economies. We suspect such an impact is unique to the emerging-market context due to the latecomer status of firms, although this is still subject to future research. As for the impact of innovation clusters of inward FDI, the extant literature based on developed economies has extensive discussion on the positive effect of innovation clusters in general (Almeida & Kogut, 1999) but not on clusters of inward FDI in particular, and thus future research is needed to detect whether our results are unique to emerging market firms.

Second, as our study has only investigated two foreign knowledge access channels, future

research could incorporate more channels. For instance, as strategic asset seeking has been recognized as an important reason for outward direct investment of firms in emerging markets (Child & Rodrigues, 2005; Luo & Tung, 2007), future research could examine how outward FDI provides knowledge acquisition opportunities and contributes to innovation by firms in emerging markets. In addition, future research, with more comprehensive datasets, could also investigate how international joint ventures, in both domestic and overseas markets, facilitate transfer of foreign knowledge to emerging-market firms. More interestingly, future research could compare the effectiveness of different channels for obtaining foreign knowledge and thus provide more meaningful suggestions for firms which intend to improve their innovative capabilities. Our research suggests that exporting may have a greater impact on innovation than does cluster-based knowledge spillovers, but we regard this conclusion as tentative and requiring further testring.

Third, besides R&D and marketing activities, future research could investigate other types of internal efforts that improve firms' ability to absorb foreign knowledge and develop their innovative capabilities. In other words, one could investigate in more depth what internal organizational characteristics lead to fundamental differences in the technological progress of emerging-market firms (e.g., cultural heritage identity in Horng & Chen [2008] and business groups in White et al. [2008]). After all, in the context of China, we only observe some firms that are capable of successfully transforming themselves from exporters without their own brands to competent competitors with well-known brands.

Fourth, as the results in the current study are based on a two-year sample, future research utilizing more years of information may capture better the dynamic learning processes of emerging-market firms as well as investigate more interesting questions such as the determinants of firms' speed in technology catch-up and acquisition of foreign knowledge.

Finally, one could also extend the current study to other emerging economies such as India to examine the external validity of the main findings. The Indian government encouraged the development of national software technology parks in the early 1990s (Altenburg et al., 2008), and thus examining knowledge spillovers associated with these parks would indicate the degree to which our results can be generalized to different countries. Also, many Indian firms have engaged in the export of IT services for more than a decade, and future research could examine the extent to which such exporting activities improve the exporters' innovative capabilities.

CONCLUSION

As more and more firms in emerging markets engage in innovative activities and aim to transform themselves from imitators to innovators, it is important to understand the factors that contribute to their innovative capabilities. Our study adopts a learning and "catch-up" perspective to suggest that access to foreign knowledge, together with investments in internal resources that enhance absorptive capacity, are crucial to the development of these capabilities. We hope that our study will stimulate future research that investigates not only firm-level learning factors but also industry characteristics and institutional environment (e.g., innovation systems) that would enable firms in emerging markets to become world-class innovators. We also hope that future research could provide a more differentiated understanding of variances in innovation patterns of firms across different emerging economies.

NOTES

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conference in Guangzhou, China, June 2008.

[1] For instance, the efforts that Stone spent in developing a new product based on the Japanese-made printer—the Brother M-2024, can be suggested by the high percentage (as high as 60%) of gross value-added on top of the cost of importing the original product from Japan (Lu, 2000).

[2] The new product ratios (the value of new products divided by the value of total output) for these two industries are respectively 0.023 and 0.027, while the average for the rest of the industries is 0.133.

[3] In our sample, "value" is the monetary quantity that the output represents given the current market price of the products. For example, new product value is the amount that a firm may receive at the market price for the new products that it produces if such sales were actually realized. But the value of the output may not coincide with sales revenue since part of the products produced in the current period may not be sold and thus become inventory. As one reviewer correctly pointed out, new product sales should be a better measure of successful innovation. Unfortunately, however, such information does not exist in the data set available to us.

[4] Dunning and Narula used the percentage of patents in a region relative to other regions to reflect the comparative advantage of a region in innovation.

[5] "*Foreign new product*" was constructed using "*new product value*" from the Census data, combined with the information of firms' ownership type, locations, and industries to which they belong.

[6] We do not have information on export sales so cannot construct an alternative measure such as export sales/revenue.

[7] Similar approach has been adopted by Shishko and Rostker (1976) in studying individuals' moonlighting behaviors and Lankford and Wyckoff (1991) in modeling charitable givings.

[8] This is an understatement of the level of product innovation by Chinese firms since this number is obtained as a simple average of the new product ratios of all firms without taking into account the fact that larger firms are more likely to engage in product innovation. If we calculate the sum of new product values by all firms in the sample and then divide it by the sum of all firms' total output, the "total" new product ratio becomes 13.3%.

[9] We did not report the elasticity for regional foreign innovation because this measure is not normalized by the industry level and thus the numerical value of the elasticity is not comparable to those of the other three explanatory variables.

[10] To avoid possible multicollinearity after including the interaction terms, we have centered the variables before constructing the interactions, following Aiken and West (1991).

[11] We did not use the two-year lag of export intensity because our 2004 data file does not contain export information. The same procedure cannot be applied to R&D intensity due to the fact that the R&D data are available in our sample only since 2005.

[12] These industries include medical and pharmaceutical products, special purpose equipment, transport equipment, electronic equipment and machinery, electronics and telecommunications, and instruments and meters.

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Table 1. Descriptive Statistics and Correlation Matrix

	Variables	Mean	St.d.	1	2	3	4	5	6	7	8	9	10	11
1	Product innovation	0.04	0.16	1.00										
2	Regional foreign innovation	0.01	0.05	0.05***	1.00									
3	Export intensity	0.48	1.67	0.04***	0.01***	1.00								
4	R&D intensity	0.71	18.88	0.04***	0.01**	0.00	1.00							
5	Marketing intensity	1.20	2.65	0.02***	0.00	0.00	0.02***	1.00						
6	State control	0.05	0.21	0.03***	0.00	-0.02***	0.01***	0.03***	1.00					
7	Size	9.71	1.33	0.17***	0.01***	0.03***	0.03***	0.04***	0.11***	1.00				
8	Age	9.69	10.24	0.04***	-0.01***	0.01***	0.01**	0.01***	0.34***	0.21***	1.00			
9	Foreign presence	0.35	0.16	0.03***	0.04***	0.02***	0.00	-0.05***	-0.07***	-0.12***	-0.06***	1.00		
10	Industry innovation	0.09	0.08	0.12***	0.02***	0.01**	0.00	-0.03***	0.05***	0.12***	0.07***	0.00	1.00	
11	Market concentration	0.06	0.13	-0.04***	-0.02***	0.00	0.01**	0.07***	0.04***	-0.03***	0.03***	-0.01***	-0.16***	1.00

Notes: N = 160702; *** p<0.01, ** p<0.05, * p<0.1.

Table 2. Product Innovations of Chinese Firms: Main Effects based on Tobit Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regional foreign innovation		0.13**		0.13**	0.12**	0.13**	0.13**
		(0.06)		(0.06)	(0.06)	(0.06)	(0.06)
Export intensity			3.19***	3.18***	3.18***	3.18***	3.18***
			(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
R&D intensity					0.07***		0.07***
					(0.01)		(0.01)
Marketing intensity						0.90***	0.89***
						(0.09)	(0.09)
State control	-0.01	-0.01	-0.004	-0.01	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Size	0.15***	0.15***	0.15***	0.15***	0.15***	0.15***	0.15***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Foreign presence	0.21***	0.22***	0.21***	0.21***	0.21***	0.22***	0.22***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Industry innovation	0.76***	0.77***	0.76***	0.76***	0.76***	0.77***	0.77***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Market concentration	-0.39***	-0.39***	-0.39***	-0.39***	-0.39***	-0.42***	-0.42***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Observations	160702	160702	160702	160702	160702	160702	160702
LR Chi2	12352.17***	12358.10***	12895.42***	12890.28***	12948.02***	12985.84***	13041.06***

Notes: Standard errors in parentheses. Results for industry, province dummy variables and the constant are not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Product Innovations of Chinese Firms: Interaction Effects with R&D Intensity based on Tobit Models

	(8)	(9)	(10)
Regional foreign innovation	0.11*	0.12**	0.11*
	(0.06)	(0.06)	(0.06)
Export intensity	3.18***	3.12***	3.13***
	(0.13)	(0.13)	(0.13)
R&D intensity	0.07***	0.10***	0.10***
	(0.01)	(0.01)	(0.01)
Marketing intensity	0.88***	0.89***	0.88***
	(0.09)	(0.09)	(0.09)
R&D intensity * Regional foreign innovation	1.57***		1.07***
	(0.34)		(0.37)
R&D intensity * Export intensity		8.31***	6.49***
		(1.60)	(1.72)
State control	-0.008	-0.01	-0.01
	(0.01)	(0.01)	(0.01)
Size	0.14***	0.14***	0.14***
	(0.00)	(0.00)	(0.00)
Age	0.002***	0.002***	0.002***
	(0.00)	(0.00)	(0.00)
Foreign presence	0.22***	0.22***	0.22***
	(0.03)	(0.03)	(0.03)
Industry innovation	0.77***	0.77***	0.77***
	(0.05)	(0.05)	(0.05)
Market concentration	-0.42***	-0.42***	-0.42***
	(0.04)	(0.04)	(0.04)
Observations	160702	160702	160702
LR Chi2	13061.98***	13067.68***	13075.92***

Notes: Standard errors in parentheses. Results for industry, province dummy variables and the constant are not reported.
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Product Innovations of Chinese Firms: Interaction Effects with Marketing Intensity based on Tobit Models

	(11)	(12)	(13)
Regional foreign innovation	0.13**	0.13**	0.13**
	(0.06)	(0.06)	(0.06)
Export intensity	3.18***	3.17***	3.17***
	(0.13)	(0.14)	(0.14)
R&D intensity	0.07***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)
Marketing intensity	0.89***	0.90***	0.89***
	(0.09)	(0.09)	(0.09)
Marketing intensity * Regional foreign innovation	0.72		0.72
	(1.24)		(1.24)
Marketing intensity * Export intensity		2.25	2.31
		(6.30)	(6.30)
State control	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)
Size	0.15***	0.15***	0.15***
	(0.00)	(0.00)	(0.00)
Age	0.002***	0.002***	0.002***
	(0.00)	(0.00)	(0.00)
Foreign presence	0.22***	0.22***	0.22***
	(0.03)	(0.03)	(0.03)
Industry innovation	0.77***	0.77***	0.77***
	(0.05)	(0.05)	(0.05)
Market concentration	-0.42***	-0.42***	-0.42***
	(0.04)	(0.04)	(0.04)
Observations	160702	160702	160702
LR Chi2	13041.38***	13041.18***	13041.51***

Notes: Standard errors in parentheses. Results for industry, province dummy variables and the constant are not reported.
*** p<0.01, ** p<0.05, * p<0.1