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Abstract

Purpose – Chinese firms were operating within a closed economic environment before the "opening up" in the late 1970s, but it has only been in the late 1990s that China has recognized the importance of innovation. The Chinese government has attempted to rectify this liability by providing funding to assist Chinese firms in developing innovation capability by increasing R&D collaborations and employing external experts. The purpose of this paper is to study the innovation of Chinese firms by examining how internal and external resources interactively impact the innovation capability.

Design/methodology/approach – Panel data collected from Chinese manufacturers are used to test the hypothesized relationships.

Findings – The results have shown that the interplay between internal and external resources exhibits differential patterns of impact on innovation capability. The authors discover different moderating patterns of the two types of external resources: visiting experts are helpful in enhancing the effects of internal human resources, while R&D collaborations are useful in exploiting internal financial and physical resources, even when the main effect of financial resources on innovation capability is not significant.

Originality/value – The study contributes to the literature by providing empirical evidences on the roles of absorbed external resources and knowledge to catalyze internal resources in building up innovation capability in an emerging economy.

Keywords China, Innovation capability, Absorptive capacity, Moderation

Paper type Research paper

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1. Introduction

Innovation capability is the ability to create new ideas, new product development, or improvements in processes and it is essential to firms' survival nowadays, especially in emerging markets such as China, which is now faced with a more dynamic and intensively competitive global environment than ever before. Chinese firms were operating within a closed economic environment before the "opening up" in the late 1970s, but it has only been in the late 1990s that Chinese firms have started to recognize the importance of innovation capability. The Chinese government has been emphasizing the development of innovation capability since its ninth five-year plan (from 1996 to 2000), and the 12th five-year plan (from 2010 to 2015) relies on the development of innovation capability to upgrade the economy from an export-driven to a domestic demand-driven economy. According to data from the National Bureau of Statistics, China's spending on research and development (R&D) has risen from 1.25 percent of GDP in 2004 to 1.75 percent in 2010 and to 2.09 percent in 2014, more impressive if considering the fact that GDP itself increased dramatically during that period. The manufacturing firms, research institutes, and other research resources, including scientists and engineers, are all encouraged to increase R&D expenditure on internal resources and form R&D collaborations with external parties. Motivated by the national plans, Chinese large- and medium-sized enterprises are increasing their R&D expenditure, which accounts for around 60 percent of the overall R&D expenditure in China (Orr, 2011). The Chinese government also provides funding and policy support to Chinese firms developing innovation capabilities through R&D collaborations and using external experts. Although there are strong motivations and obvious achievements, there remain questions on the effectiveness and efficiency of resource allocation, given the large amount of R&D expenditure, and on how Chinese firms could quickly build up innovation capability based on both internal resources and external knowledge sources.

The capability to innovate is among the most important factors that will help a firm to achieve and sustain its competitive advantage (Hult *et al.*, 2004). Prior literature on resource-based view (RBV) has argued that a firm is composed of valuable and inimitable resources that determine its competitive advantage (Barney, 1991; Teece and Al-Aali, 2011). Knowledge-based view (KBV) further argues that knowledge, explicit information and tacit know-how (Kogut and Zander, 1992), is an intangible strategic resource and firms can gain competitive advantages by combining and creating knowledge (Grant, 1996; Nonaka, 1994). However, firms not only have to possess internal resources or knowledge to enhance innovation capability (Del Canto *et al.*, 1999) but also need to establish linkages with their partners in the network to leverage on external resources and knowledge (Zhang *et al.*, 2010), which could be conceptualized as absorptive capacity (Cohen and Levinthal, 1990). Absorptive capacity is constituted by a set of organizational routines and processes that enable the firm to explore, transform, and exploit knowledge from different sources (Cohen and Levinthal, 1990; Todorova and Durisin, 2007; Volberda *et al.*, 2010). For manufacturing firms, new knowledge often comes from external sources such as suppliers or customers (Dyer and Hatch, 2006). It is also well documented that collaborative arrangements often lead to inter-organizational learning which can increase the innovation capability of the parties involved (Lyles and Salk, 1996; Tsai, 2001). Although some studies have already found positive results regarding the effects of internal resources and knowledge transfer on innovation and firm performance (Zhang *et al.*, 2007, 2010), there remains a need to investigate how internal and external resources jointly contribute to the development of innovation capability, especially in emerging markets where external collaborations with foreign firms and experts are encouraged by the government and policy makers to complement domestic resources. The interplay between internal and external knowledge represents the development of firms' absorptive capacity, but the mechanism by which their interaction effects contribute to innovation is still not well understood. Moreover, there are also mixed findings concerning the interaction effects of internal and external resources (Espedal, 2005; Sorge, 2006; Su *et al.*, 2009). To fill these research gaps, this study tries to address the following research question: how do internal and external resources jointly affect the development of innovation capability for Chinese manufacturers? Based on the perspective of absorptive capacity, we use secondary data collected by the Guangdong Provincial Technology Center Assessment Program (GPTCAP) in China to address the research questions and test the hypothesized relationships.

2. Theory and hypotheses

2.1 Theoretical background and research model

Previous research indicates that internal resources play a critical role in enhancing innovation performance (Caloghirou *et al.*, 2004; Huang and Lin, 2006; Lu *et al.*, 2015). For example, an empirical study in seven European countries has shown that investments in R&D and human resources contribute to innovation performance (Caloghirou *et al.*, 2004). Financial, human, and physical resources are all seen as important internal resources in R&D activities (Barney, 1991). Firms use physical resources to conduct experiments or product engineering required by innovation or imitation. The experimental instruments and facilities for engineering and production, together with R&D-related IT systems, have been found to have a positive impact on innovation (Mitchell and Zmud, 1999). Skilled technical employees are often sources of new ideas on product innovations or improvements. R&D-related financial resources are also an important factor in supporting and sustaining innovation (Romijn and Albaladejo, 2002).

In addition to internal resources and knowledge, the importance of knowledge and expertise from external sources in the innovation process has also been validated by several studies (Caloghirou *et al.*, 2004; Romijn and Albaladejo, 2002; Rothwell, 1991; Rothwell and Dodgson, 1991). Knowledge can be classified as explicit knowledge or information, and tacit knowledge or know-how (Kogut and Zander, 1992), and new knowledge can be created through the conversion between tacit and explicit knowledge (Nonaka, 1994). Firms can acquire knowledge from external partners through special procedures and interactions (Hult *et al.*, 2004; Jansen *et al.,* 2005). External connections with organizations including universities, research institutes, and other companies can provide important inputs to build up innovation capability (Boardman and Ponomariov, 2009). Social interactions in terms of individualized and in-depth working relationships with external experts can also boost knowledge transfer by facilitating the transfer of important tacit knowledge.

Based on either RBV or KBV, previous studies have investigated the effects of internal or external resources/knowledge on innovation, while a more specific theoretical lens, absorptive capacity, will be suited to study how preexisting organizational resources/knowledge and absorbed resources/knowledge could be incorporated by manufacturers (Patel *et al.*, 2012; Tu *et al.*, 2006) to improve innovation capability. Absorptive capacity was defined as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p. 128). Actually in their early seminal work, Cohen and

Levinthal (1990) introduced this term to study the ability of a firm to innovate, and they also argued that it is path dependent and influenced by a firm's prior knowledge. Further work has extended the concept of absorptive capacity into more detailed process models with antecedents, outcomes, and contingencies. In these studies, the main focus has been on conceptualizing knowledge acquisition, assimilation, transformation, and exploitation in the process model (Lane *et al.*, 2006; Todorova and Durisin, 2007; Zahra and George, 2002) and validating each dimension (Jansen *et al.*, 2005).

In this study, we adopt the theoretical lens of absorptive capacity and aim to empirically investigate how firms rely on internal and external resources jointly to build up innovation capability. Further, we try to operationalize internal and external resources using objective data in order that the findings could be easily replicated and examined in other contexts, as mixed results are often found in existing literature (e.g. Escribano *et al.*, 2009; Lee *et al.*, 2001, Soh and Roberts, 2005; Su *et al.*, 2009) due to discrepancies in measurements, methodologies, and contexts.

By focussing on the context of an emerging economy, China, in which rapidly growing opportunities have created unique challenges to knowledge transfer within firm networks (Hitt *et al.*, 2005; Hoskisson *et al.*, 2000; Li and Atuahene-Gima, 2002), this study could also enrich the current understanding on absorptive capacity. Typically, firms in emerging economies are late-comers when it comes to innovation, so they have to work harder to catch up (Li *et al.*, 2010). Organizational theorists, including Child and Rodrigues (2005), have examined the motives for internationalization of prominent market-seeking Chinese firms and suggest that traditional western theories ignore the fact that firms from emerging economies like China often have to overcome disadvantages rather than to exploit advantages. The recent cases in China often support this by showing a lack of innovativeness among Chinese manufacturers, which indeed has created shortages and setbacks in technology accumulation and breakthrough. Therefore, the Chinese government recognizes these challenges for its local manufacturing firms and is now encouraging local firms to increase their innovativeness by partnering with foreign firms and experts (Lee *et al.*, 2011; Motohashi and Yun, 2007). For example, China's 12th five-year plan (from 2010 to 2015) has emphasized on the university-industry collaborations and industry innovation alliances. The hope is that by doing this the local firms will enhance their innovative capabilities. The Chinese government also expects more innovations from enterprises, including startups and SMEs, and encourages a large number of firms with accesses/connections to each other to form alliances, and it is believed that "the development of industrial clusters will improve the innovation capability of SMEs." The 12th five-year plan also suggests that "the flow and accumulation of innovation elements to enterprises should be directed and supported." China is trying to make the leap from being a manufacturer of goods, often for others, to being a world-class innovator. Malik and Wei (2011) also provide cases of SMEs that the government has actively promoted and supported the visits of foreign experts to work in China and the R&D collaborations of Chinese firms with universities, research institutes, and supply chain partners. It is recognized that local manufacturers could absorb explicit and tacit knowledge regarding product or process innovation from external firms, R&D institutions, and experts in the business network (Dyer and Hatch, 2006; Hitt *et al.*, 2005).

In the theoretical model (Figure 1), firms utilize and combine the internal and external resources to build up innovation capability. In this study, R&D collaborations

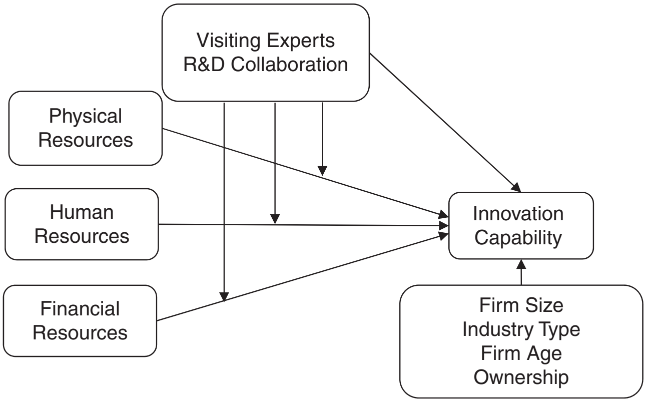

Figure 1.
Theoretical model

with other firms and visiting experts that temporarily work full-time in the company are used as indicators for potential sources of external knowledge, which is also consistent with the practices recommended by Chinese government. Visiting experts may come from domestic or foreign universities, research institutes, suppliers, customers, and/or other companies. Consistent with previous research, the investments in the financial, human, and physical aspects of R&D activities are seen as important internal resources for the development of innovation capability.

2.2 Interactions between internal and external resources

Internal resources mainly enhance a firm's ability to create new products/processes or improve existing products/processes itself, while external resources expand a firm's access to new knowledge and new applications of their existing knowledge. Cohen and Levinthal (1990, p. 128) suggest that "the ability to exploit external knowledge is a critical component of innovative capabilities." Firms with high-level external connections can facilitate knowledge sharing (Chow and Chan, 2008) externally and internally, thus the interaction between internal and external resources becomes critical for the development of firms' innovation capability (Teece and Al-Aali, 2011). For example, Steensma *et al.* (2012) suggested that there is a compensatory relationship between internal technological resources and external social interactions.

R&D-related physical resources directly contribute to the development of innovation capability. The R&D equipment and experimental instruments allow companies to study supplied materials or test final products (Simonin, 1999). But to maximize the output of physical resources, firms need to figure out how to utilize them more efficiently and creatively. Although Chinese manufacturers may be able to afford the advanced R&D instruments, they may lack the knowledge and experience in fully using them. By involving external parties in the organizational processes, including knowledge acquisition, assimilation, transformation, and exploitation (Cohen and Levinthal, 1990; Todorova and Durisin, 2007), the advanced R&D instruments purchased might be better utilized to generate extra value. Empirical studies have also shown that absorptive capacity is a contingent factor for opportunity recognition, alliance formation, and accumulation of embedded knowledge from social networks (Tsai, 2001; Escribano *et al.*, 2009). The tacit knowledge of external experts could be transferred to the internal staff when they are working together using the experiment equipment. By employing external experts or working in R&D collaborations with external parties, the potential of R&D instruments and other physical facilities could be better explored, allowing firms to tackle the state-of-the-art problems and invent core product innovations which are technologically advanced and patentable. Therefore, we expect that external experts and R&D collaborations positively moderate the role of physical resources in enhancing innovation capability:

H1a. Visiting experts positively moderate the impact of physical resources on innovation capability.

H1b. R&D collaborations positively moderate the impact of physical resources on innovation capability.

Human resources (technological personnel in particular) play an important role in building up innovation capability (Caloghirou *et al.*, 2004; Chen and Huang, 2009; Laursen and Foss, 2003). External experts can educate and train the technical personnel, which helps the focal firm to build up its own knowledge and resources base for innovation (Caloghirou *et al.*, 2004). The tacit knowledge of external experts could help internal technical personnel in understanding new technologies, identifying and resolving problems, or exploiting existing knowledge. The diversity of knowledge generated by the combination of internal and external knowledge sources also increases the possibilities for innovative ideas (West, 2002). In R&D collaborations, internal technical personnel interact with employees of other companies to enable knowledge acquisition, dissemination, and embodiment (Cummings and Teng, 2003). As suggested by Inkpen (1998), R&D collaboration creates a stimulating environment for knowledge crystallization and amplification. We thus expect the following:

H2a. Visiting experts moderate positively the impact of human resources on innovation capability.

H2b. R&D collaborations moderate positively the impact of human resources on innovation capability.

As found by previous studies, financial resources are necessary for innovation capability building. Not only being knowledge-intensive, the innovation process is also a financial capital-intensive process (Del Canto *et al.*, 1999), as various R&D-related activities require substantial financial support. Firms' high R&D expenditures contribute to internal R&D capability (Romijn and Albaladejo, 2002). In addition to the direct effects of financial resources, Lee *et al.* (2001) also found the interaction effects of financial resources and external linkages on firm performance to be significantly positive in technology-based ventures. Visiting experts with expertise in technological or industrial issues may provide constructive suggestions on project selections, technology roadmap, or other innovation activities, which all enhance the effectiveness of financial resources allocated. R&D collaborations with external partners could enhance the possibility of the R&D project success by sharing knowledge and risks, and assets supplementary to the focal firm's financial resources can also be provided by the collaboration partners. Therefore, we expect the following:

H3a. Visiting experts positively moderate the impact of financial resources on innovation capability.

H3b. R&D collaborations positively moderate the impact of financial resources on innovation capability.

3. Methodology

3.1 Sample and data source

We use panel data from a sample of Chinese firms enrolled in GPTCAP from 2003 to 2007. The objective of GPTCAP is to help firms improve competitiveness and innovation capability. Once certified by the program, firms may enjoy benefits provided by the government, such as favorable tax breaks and external financial support for R&D projects. All firms in Guangdong province (the most important manufacturing province in China) can apply; however, several basic requirements must be met: total technological expenditure should be larger than six million Chinese yuan, accounting for at least 3 percent of the product sales; the number of technological personnel should be more than 50; and the original value of all R&D equipments should be larger than five million Chinese Yuan. In addition to these quantitative requirements, certain qualitative ones are stated such as having strong technological capability, holding a good competitive position in its industry, showing a good organizational R&D structure, having collaborations with university and research institutes, etc.

Every year, companies need to go through a strict application and evaluation process. First, companies provide both quantitative and qualitative data and additional documentation in the application process. One document is Annual Census on Technological Activities of Large and Medium Industrial Enterprises, which is conducted by the National Bureau of Statistics of China (NBSC). If a company did not participate in the survey conducted by the NBSC, it needs to provide the same information according to the format of the survey. In addition, the company has to provide descriptions of certain quantitative data in the Table AI. For example, in the survey if the company has indicated five patents applied in a year, it has to provide a list containing the patent name and other basic information. This is done likewise for other variables (e.g. the man-month of visiting experts work in the company, the number of R&D collaboration undertaken, the number of prizes received, etc.) in order to ensure the validity of the data. Moreover, the company also needs to provide its accounting report which has to be certified by the relevant local governmental departments (e.g. Economic and Trade Commission, Administration of Taxation, Administration of Customs). After the companies turn in the applications together with the supporting documents, all applications will be assessed by a team of experts composed of officers from the Economic and Trade Commission and professors from a university. To check the data and assess the application, sometimes the experts need to conduct on-site interviews. A complex evaluation system is employed in the assessment process and a certificate will be issued if the company meets the standard. If a company is found to falsify data, the certificate will be withdrawn and the company will be denied in certification program for three years as sanctions. The above procedures guarantee the authenticity of the data and help to enhance the validity and reliability of the data.

The database includes 90, 122, 150, 163, and 180 firms, respectively, for years from 2003 to 2007. To reduce the unobserved heterogeneity, we selected only manufacturing firms with at least two years of data available. To meet these two criteria, a number of firms in each year were excluded. The final sample sizes and average values of the variables are described in Table I, and Table II shows the sample distribution across industries.

3.2 Operationalization of variables

3.2.1 Dependent and independent variables. In this study the dependent variable, innovation capability, is denoted by the firm's capabilities in creating product and

Table I. Basic information of the sample

Description of indicators	2003	2004	2005	2006	2007
Average of overall revenue[a]	208,381.4	201,816.4	249,067.4	255,950.2	279,618.7
Average no. of years since the company's startup	24.73	22.88	22.22	22.10	21.58
Average no. of months of visiting experts per year	25.77	25.87	31.44	35.86	33.14
Average no. of R&D collaborations per year	5.90	5.70	5.75	6.48	13.72
Average value of R&D expenditure	6,098.29	9,482.39	7,348.13	8,071.14	8,698.59
Average no. of patents per year	10.58	13.36	14.44	12.52	17.79
Average no. of technical personnel per year	246.78	236.65	260.10	281.76	336.86
Average value of new R&D equipment that was purchased in last 3 years[a]	2,347.09	3,809.73	3,505.81	2,526.79	3,350.05
Sample size	73	106	135	147	173

Note: [a]The unit is 10,000 Chinese yuan

Table II. Distribution of sample across industry

	Overall		Between	
Industry	Freq.	Percent	Freq.	Percent
Food, beverage, tobacco	32	5.05	9	5.00
Electronics, computer, communication	79	12.46	21	11.67
Textile, apparel, leather	12	1.89	3	1.67
Electrical appliance (home appliance)	141	22.24	43	23.89
Transportation equipment	30	4.73	9	5.00
Machine	92	14.51	25	13.89
Rubber and plastics	21	3.31	5	2.78
Chemicals and pharmaceuticals	110	17.35	30	16.67
Ceramics	39	6.15	14	7.78
Metal	38	5.99	10	5.56
Furniture	5	0.79	1	0.56
Printing	5	0.79	1	0.56
Stationary	8	1.26	2	1.11
Metallurgy	22	3.47	7	3.89
Total	634	100.00	180	100.00

process patents. It is thus measured by the number of acquired patents for each firm-year observation, which has been commonly used as a proxy for innovation (e.g. Mazzola *et al.*, 2015; Phelps, 2010). R&D intensity or patent-based proxies have been largely used for measuring firms' innovation capability or absorptive capacity (Nag and Gioia, 2012; Schildt *et al.*, 2012; Tsai, 2001). Although using the number of patents as a proxy to measure innovation capability has some limitations (e.g. some inventions are not patentable), the number of patents is still commonly used as a reflection of the innovation capability of firms, especially in the Chinese context where technological innovations often need to be patented to protect intellectual property.

In previous literature, external resource was conceptualized in different ways. For example, Romijn and Albaladejo (2002) stated that external resource consists of intensity of networking, proximity advantages related to networking, and receipt of institutional support. Rothaermel (2001) used the number of the strategic alliances, while Lee *et al.* (2001) referred to external resource as partner-based and sponsor-based linkages. Therefore, there is no consistency of measurements because of the variety in conceptualization. In most cases, measurement has been taken by the number of events/activities that occur. In this study, the external resources are conceptualized as involving either visiting experts or R&D collaborations, measured by the actual total number of months that all domestic and overseas external experts work in the focal firm for each year and the number of the collaborative R&D projects in each year. As such, these two indicators of external resources reflect the intensity of collaborations with external parties in R&D. To avoid any confounding effects, the variables of visiting experts and R&D collaborations are standardized by firm size (the natural logarithm value of overall revenue).

Similarly, regarding the internal resources in R&D, as the amount of R&D-related firm assets and investments are closely correlated with firm size, a ratio was used to represent the internal efforts in different aspects in order to compare firms in different industries with different sizes. To categorize the three aspects of internal resources, namely, financial, human and physical resources, different ratios were applied and detailed definitions and operationalization are listed in Table AI.

3.2.2 Control variables. Four control variables were added to rule out alternative explanations. First, a larger firm may offer greater scope for market and technological opportunities. This enables the firm to leverage its internal and external resources/capabilities for successful innovation. Here, we measured firm size using the natural logarithm value of total revenue. Second, there are different market and technological opportunities in different industries. In our study, there are 14 industries and the industry information was used as categorical variables divided into 13 dummy variables for the regression equations. Third, three dummies of ownership (state-owned, private-owned, joint venture, foreign-owned) were included. Finally, firm age measured by the number of years since its startup was included as a control variable.

3.3 Empirical model specification

Count regression model was employed to analyze the data. Count regression model was used because the dependent variable (number of patents) belonged to the counted data (Czarnitzki *et al.*, 2009; Hausman *et al.*, 1984; Quintana-García and Benavides-Velasco, 2008; Scott and Freese, 2006). As an extension of the Poisson regression, negative binomial estimation was used to test the model due to the over-dispersion of zeros in the dependent variable. In our negative binomial model, the probability that the number of patent would occur n times is represented represented as follows:

$$\Pr\left(y_i \middle| x_i, \delta_i\right) = \frac{e^{-\tilde{\mu}_1}\tilde{\mu_1}^{y_i}}{y_i!},$$

where $\tilde{\mu_1} = \exp(B_j X_{ij})\exp(\varepsilon_i) = \exp(B_j X_{ij})\delta_i$ and e^{ε_i} are drawn from a gamma distribution. In the equation, y_i is the random variable indicating the number of times that the company applied the patent in one year, and x_i the variable representing the internal and external resource/investment in one year. In the negative binomial model, ε_i is an unobserved and omitted variable reflecting the unobserved heterogeneity among observations. To estimate our models, the Stata program is used, which allows the estimation of the negative binomial models in the panel data. The Stata command "xtnbreg" is used to estimate the model. In this study, random-effects specification is adopted to control for the unobserved heterogeneity. The Hausman specification test is conducted and its results showed that a random-effects specification is appropriate.

To test the additive effects of control variables, external and internal resources, and the interaction between the two, various models had been run for the dependent variable. The first model with only control variables was used as a benchmark model to show the effects of control variables on innovation capability. The second model used both control variables and internal and external resources in order to test the positive global effects of internal and external resources, as compared to the first model. The third model added interactions between internal and external resources. To test the interaction effects, six interaction terms (three internal multiplied by two external resource variables) were produced. But not not all interaction terms terms were simultaneously added in a single model because of two issues: first, the correlations between interaction terms would be high, which may lead to multi-collinearity problems; second, the sample size of this study was not large enough to perform the test in which all interaction terms are included in one single model. Therefore, the moderating effects of the two external resources were tested, with one internal resource variable each time. Finally, three groups (physical, human, and financial resources) of models were organized. To reduce the potential multi-collinearity problem from independent variables and their interactions, the mean-center technique was used to create the interaction terms (Aiken *et al.*, 1991).

4. Results

4.1 Descriptive statistics and correlations

Table III presents the mean, standard deviations, and correlations of all variables. Table IV summarizes the statistical findings from the negative binomial regressions explaining innovation capability. To address the multi-collinearity concern, variance inflation factor (VIF) was computed. The VIF values ranged from 1.03 to 1.06, which were far below the recommended cutoff value of 10 (Kutner *et al.*, 2004), indicating that multi-collinearity is not a problem in this study.

4.2 Hypothesis testing results

Due to the lag between R&D input and output, it would be better to build our model with appropriate lag structure. However, many missing values exist when considering the lagged patent in our data. Moreover, serial correlation is usually so strong in R&D resources that using the R&D resources and patent data at the same time may not cause serious problem (Hall and Ziedonis, 2001; Motohashi, 2005). With data for

	1	2	3	4	5	6	7	8
1. Firm size	1.00							
2. Firm age	0.06	1.00						
3. Visting experts	0.33***	0.05	1.00					
4. R&D collaborations	0.24***	0.05	0.02	1.00				
5. Financial resources	−0.31***	0.03	0.00	−0.07	1.00			
6. Human resources	−0.21***	−0.14***	0.02	−0.02	0.20***	1.00		
7. Physical resources	−0.11**	−0.03	−0.01	−0.03	0.06	0.18***	1.00	
8. Innovation capability	0.41***	−0.06	0.39***	0.38***	−0.06	−0.07****	−0.06	1.00
Mean	11.28	22.41	2.66	0.65	0.05	0.12	0.03	14.28
SD	1.28	12.92	3.14	2.39	0.04	0.10	0.07	39.60

Notes: 180 groups and 634 observations. $^{**}p < 0.01$; $^{***}p < 0.001$; $^{****}p < 0.1$

Table III. Descriptive statistics and correlation matrix

Physical resource			
Innovation capability	Model 1	Model 2a	Model 3a
Intercept	−4.002 (0.880)***	−3.836 (0.871)***	−4.028 (0.883)***
Industry dummies	Included	Included	Included
Ownership dummies	Included	Included	Included
Firm age	−0.011 (0.006)****	−0.012 (0.006)*	−0.012 (0.006)*
Firm size	0.315 (0.055)***	0.296 (0.054)***	0.301 (0.055)***
Visiting experts		0.048 (0.012)***	0.047 (0.012)***
R&D collaborations		0.040 (0.006)***	0.111 (0.035)**
Physical resource (PR)		0.937 (0.524)****	1.225 (0.629)****
Visiting experts-PR			0.188 (0.231)
R&D collaborations-PR			2.436 (1.251)****
Log likelihood	−1,831.36	−1,811.50	−1,803.89
χ^2	77.34	176.85	185.19
Improvement over base		39.72***	4.88****
Observations/groups	634/180	634/180	634/180
Human resource			
Innovation capability	Model 1	Model 2b	Model 3b
Intercept	−4.002 (0.880)***	−4.200 (0.878)***	−4.232 (0.880)***
Industry dummies	Included	Included	Included
Ownership dummies	Included	Included	Included
Firm age	−0.011 (0.006)****	−0.011 (0.006)****	−0.011 (0.006)****
Firm size	0.315 (0.055)***	0.313 (0.055)***	0.311 (0.055)***
Visiting experts		0.048 (0.012)***	0.056 (0.013)***
R&D collaborations		0.038 (0.006)***	0.041 (0.009)***
Human resources (HR)		2.006 (0.559)***	2.100 (0.560)***
Visiting experts-HR			0.330 (0.140)*
R&D collaborations-HR			0.128 (0.277)
Log likelihood	−1,831.36	−1,806.61	−1,803.77
χ^2	77.34	187.25	194.64
Improvement over base		49.50***	5.69****
Observations/groups	634/180	634/180	634/180
Financial resource			
Innovation capability	Model 1	Model 2c	Model 3c
Intercept	−4.002 (0.880)***	−4.047 (0.881)***	−4.006 (0.885)***
Industry dummies	Included	Included	Included
Ownership dummies	Included	Included	Included
Firm age	−0.011 (0.006)****	−0.012 (0.006)*	−0.012 (0.006)*
Firm size	0.315 (0.055)***	0.309 (0.055)***	0.293 (0.056)***
Visiting experts		0.046 (0.012)***	0.046 (0.012)***
R&D collaborations		0.040 (0.006)***	0.175 (0.053)***
Financial resources (FR)		1.314 (1.224)	1.717 (1.218)
Visiting experts-FR			−0.491 (0.340)
R&D collaborations-FR			4.689 (1.818)**
Log likelihood	−1,831.36	−1,812.24	−1,808.79
χ^2	77.34	177.67	184.64
Improvement over base		38.24***	6.90*
Observations/groups	634/180	634/180	634/180

Notes: The number in bracket is the standardized error for the regression coefficient. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; $****p < 0.1$

Table IV.
Regression results

eight years, Hall *et al.* (1986) tested the relationships between R&D and patents. Their results showed a contemporaneous relationship between R&D and patenting. Further, the lag structure may not be consistent across different industries.

A series of tests comparing successive models using incremental *F*-tests were conducted. In Table IV, Model 1 only included control variables. The additive tests in Model 2a-c included both control variables, external resource variables, and internal resource variables, explaining innovation capability in a significantly better manner than that in Model 1 ($p < 0.01$). Furthermore, interaction terms in Model 3a-c were added to test the interaction effects.

H1, *H2*, and *H3* propose that external resources positively moderate the effects of internal resources on innovation capability. The effects of interaction terms were mixed in general. Out of six possible interaction terms, three were positive and statistically significant but the other three were statistically non-significant. The results in each pair of Models (2a and 3a, 2b and 3b, and 2c and 3c) were compared in order to examine the interaction effects. Among the three types of internal resources, each internal resource has statistically significant interactive effects with at least one external resource indicator. While R&D collaborations significantly enhance the effects of financial and physical resources on innovation capability, the interaction effects of visiting expert and these two resources are not statistically significant. While visiting experts significantly enhance the positive effects of human resource on innovation capability, the interaction effects of R&D collaboration and human resource are not statistically significant. Therefore, *H1b*, *H2a*, and *H3b* are supported while *H1a*, *H2b*, and *H3a* are not supported.

5. Discussion

5.1 Theoretical contributions

This study has empirically shown that the interplay between internal and external resources exhibits differential patterns of impact on innovation capability in the context of an emerging economy, which contributes to existing literature in several ways. First, we extend the previous research which mainly followed RBV or KBV and focussed on how firms acquire internal or external resources/knowledge to improve innovation capability and competitive advantage, by investigating how the interactions of internal and external resources contribute to innovation from the theoretical lens of absorptive capacity. Specifically, the interaction of financial resources with R&D collaborations has the most important impact on innovation capability, although financial resources do not even have a significant direct effect on innovation capability; human resources exhibit both significant main effect and significant interaction effect with visiting experts on innovation capability; physical resources show significant main effect and interaction effect with R&D collaborations on innovation capability. Only three of the six interaction effects have been found significantly positive, indicating that the effectiveness of a firm's absorptive capacity is contingent on the configurations of internal and external resources.

Second, we discover different moderating patterns of the two types of external resources. Visiting experts are helpful in enhancing the effects of human resources, while R&D collaborations are useful in exploiting financial and physical resources. By showing this difference, our findings show how absorptive capacity specifically enables firms to incorporate absorbed resources and knowledge with their preexisting resources and knowledge to improve innovation capability. Our findings contradict intuitive perceptions that internal resources/capabilities should be more important to innovation than external resources (Caloghirou *et al.*, 2004; Lee *et al.*, 2001), as we actually find that the external sources of knowledge have both significant main and significant interaction effects that positively affect the innovation capability. Further, this difference also suggests that the two types of external resources are complementary to each other in better catalyzing preexisting internal resources and knowledge.

Finally, our findings could confirm the positive impact that the governmental and policy supports to external R&D partnerships in emerging economies have on innovation. Actually an exemplary company covered in our sample has now been regarded as one of the greatest innovative companies in China and globally as well, and it was reported that this company applied 3,442 patents in the year 2014, which was ranked the first globally by the World Intellectual Property Organization. However, we also find that in China the governmental efforts to stimulate financial expenditure on R&D cannot improve innovation capability significantly with the absence of external knowledge sources, which has important implications for policy makers. The insignificant main effect of financial resources on innovation capability indicates that a high ratio of investment in R&D projects may not significantly improve innovation capability in terms of the number of patents. Czarnitzki *et al.* (2009) also identified differential contributions of R&D and found that there is a significant premium for the portion of R in R&D for patenting. In China it might indicate that the largest portion of R&D may focus on development rather than research. This is also consistent with the findings that many of the foreign invested firms are responsible for much of the high-tech exports from China (Zhang *et al.*, 2007). In global markets, most Chinese manufacturers are in the low end of the value chain even though China has a large portion of high-tech exports. However, when the financial resource input to R&D is combined with efforts on R&D collaborations, the financial investment in R&D becomes effective for creating innovation capability. This finding shows that R&D collaboration significantly enhances the effectiveness of the firm's use of financial resources for research and development activities.

5.2 Limitations and future research

Our research shows how manufacturing firms in a large emerging economy attempt to develop their own innovation capability. Although it is likely that firms in some other emerging markets may behave differently from Chinese firms, the innovation challenges faced by firms in emerging markets are similar. For example, Chong *et al.* (2011) found that supply chain management practices in both the upstream and the downstream supply chain have a direct and significant impact on organizational and innovation performance of Malaysian firms. Further comparative studies among emerging economies such as India and Brazil would provide more insights concerning how firms in emerging economies develop their own capabilities or whether they continue to rely on external (a lot of times, foreign) sources of innovation. This study also has several other weaknesses. First our data collection from the GPTCAP may have led to a sampling bias of only innovative companies, although manufacturers in Guangdong province of China are representing the main force in "the world's factory." Second, although secondary data allowed us to use proxies for external resources and innovation capability, the quality of external resources and innovation have not been captured in this study, which could be addressed by further research using primary Likert scale-based measurements. Finally, the data were self-reported by the managers of the firms (although objective and complemented by supporting documents); thus, there still might be a bias that managers value external ideas and innovations higher than those internally developed. For example, Menon and Pfeffer (2003) find evidence that firms often do not value their internal innovative resources as highly as they value external knowledge, leading to a tendency to undervalue some of the internally generated innovations. It is a good area for future research to explore whether the collaborations and learning among supply chains partners in close relationships do produce innovations that are superior to internally generated innovations. Nevertheless, these limitations provide research opportunities for future studies.

6. Conclusions

This study investigates the mechanism by which Chinese manufacturers build up innovation capability by absorbing absorbing external resources and knowledge to catalyze internal resources. Absorptive capacity – the ability to value, assimilate, and utilize external knowledge – positively moderates the effects of firms' internal resources on their innovation capability.

There are several managerial implications for Chinese manufacturing firms. First, technical employees are very important assets for knowledge creation and absorption; thus, well-designed reward systems for them will help to build up innovation capability. Second, external resources such as experts and collaborating firms are important knowledge sources; thus, inviting inviting overseas experts or collaborating with western companies who already have the core technologies might be a more efficient way to develop internal capabilities than doing it all alone. Finally, our results can assist government decision-makers to make appropriate and specific decisions on policies and financial support accordingly to build the country-level innovation systems (Chang and Shih, 2004) rather than generally supporting all sorts of R&D activities and collaborations.

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Appendix

Variable description	Definition
Innovation capability	The number of acquired patents for each firm-year observation
Visiting experts	The number of months the domestic and oversea experts work in the company for each firm-year observation[a]
R&D collaborations	The number of R&D collaborations with other organizations conducted within the year of observation[a]
Financial resources	The ratio of technological expenditure on R&D project to total product sale in each year
Human resources	The ratio of the number of technological personnel to the total number of employees
Physical resources	The ratio of the value of new R&D equipment purchased in the last three years to the overall revenue of the year
Firm size	The natural logarithm value of overall revenue
Industry dummies	Thirteen industry dummies are created from 14 industry types
Firm age	The number of years since the company's startup

Note: [a]For visiting expert and R&D cooperation, the number is standardized by firm size (the natural logarithm value of overall revenue)

Table AI. Variables definition

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