

Accumulation of Technological Innovation Capability and
Competitive Performance in Chinese firms:
A quantitative study

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Abstract

This paper tries to contribute to the emerging research stream on technology creation in China. We investigated whether technology strategy, expressed in terms of different technological innovation capabilities has an impact on competitive performance in Chinese firms. The research is based on a sample of 215 technology-based companies in China – including foreign, domestic private and state-owned companies. The three sets of technological innovation capabilities – investment, production and linkages are inspired from the framework of Lall (1992). We then analyze the impact of these three sets of technology capabilities on firm competitive performance along three distinct lines: innovation performance, sales performance and product competitiveness. These are the basis of our hypotheses. Data reveals a significant positive relationship between the accumulation of the firm's technological innovation capabilities and its competitive performance. However, the results may differ with different performance indicator. Specifically, this study finds that investment in in-house R&D has a positive relationship on all the three performance indicators. All the technological capabilities related to investment, production and linkage, exert positive influence on product performance. Besides, the importance of duplicative capability is also highlighted in determining the innovation performance in Chinese firms. Finally, managerial implications are discussed and a brief conclusion is presented.

Keywords : technological innovation capability, technological strategy, technology catch-up, firm performance, Chinese firms

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1. Introduction

The two major issues facing the world economic system today are the globalization and the technological change. Both of them create and foreclose opportunities for the emerging countries to enhance their technological innovation capability (TIC) which is considered as the main driver of competitiveness and long-term economic development. Over the past three decades, many studies have looked at the process of successful technological learning and TIC building in the industrialization of developing countries (Kim, 1997; Bell, 2006; Arvanitis, 2006; Tacla and Figueiredo, 2006; Dodgson, 2009). It is believed that, in general, newly industrialized countries initially learn technologies from developed countries, and then build their own TIC step by step. In fact, the story of TIC building is also related to the catch-up theory originally proposed by Gershenkron (1962) and Perez and Soete (1988), and later studied in Hobday (1995), Lee and Lim (2001), Kim and al. (2004), Lee and al. (2005) and Lee (2007).

On the question of whether a less developed economy can catch up with the so-called information revolution, some scholars (Ernst and O'Connor, 1992) claimed that developing countries are too far behind to benefit from such an advanced technology. They argued that rapid technical change has produced very steep entry barriers in sectors, where its implementation requires huge and rising R&D investment, and where economies of scale and learning are of critical importance. By contrast to Ernst and O'Connor, an entirely different conclusion was reached by Soete (1985). Soete argued that competition among industrialized nations may accelerate the transfer of innovations from market leaders to newly industrializing countries. 'Leapfrogging' is a viable and likely strategy to newly industrializing countries, where scientific and technical education does not present a major bottleneck to the absorption of the relevant technologies. Soete's view was supported by some newly industrializing countries such as South Korea, Taiwan and Singapore, that successfully moved from Original Equipment Manufacture (OEM) of foreign design to their own-based marketing.

If there is to be "catch-up", one requirement is the selection of appropriate technology, that can be best fitted within given local resources or environment, and can eventually contribute to a country's long-term economic development (Rosenberg, 1976; Fransman, 1984, 1986; Stewart, 1984; Ranis, 1984; Lall, 1987; Lall and Teubal, 1998). Developing countries generally import technologies from technology suppliers in developed countries. Where the pace of the technology changes too quickly, and where the importing country does not have adequate endowment to fit the advanced technology, it is very unlikely that the importing country can benefit from it in a long-term. Nevertheless, if starting from appropriate technologies perhaps not advanced in terms of the world standards but advanced in the domestic market, developing countries can benefit from appropriate technologies more, as long as those countries can provide the necessary human and physical capital.

Another requirement is to assimilate acquired technologies effectively. Technology cannot be passively imported without any effort to absorb it. Given the idiosyncratic and tacit aspects, once imported, technology needs at least to be adjusted to meet specific aspects of local demands (Fransman, 1984, Lall, 1992, 1994; Bell and Pavitt, 1993, 1995). This relates to the issue of TIC building. Developing countries need to

create, perhaps rather than strengthen their TICs, which will be the foundation of sustained economic growth (Lall 2001). If they have the ability to recognize an opportunity for technological input, the capacity to seek and select the appropriate technologies, the ability to adapt to local conditions, the skill to modify technologies, the know-how to generate new processes and products, finally less developed countries can catch up in the advanced technology (Fransman, 1984 and Kim 1997, 1999).

The economic reforms process in China started in 1978. These reforms have improved Chinese living standards dramatically and brought China into the global business world. At the height of the Industrial Revolution, Britain was called “the workshop of the world”. That title surely belongs to China today. However, China now faces the challenge of ensuring the further progress in the economic, social and environmental filed. This will require fostering innovation in both national and firm level, which can plan a major role in achieving that goal.

This study takes Chinese firms as an example, tries to make a contribution to that debate by providing research and analysis that answers two important questions – what are those technology strategies, expressed in terms of TICs have been adopted and do those TICs really have an impact on firm competitive performance? This paper tries to explore these questions based on a sample of 215 technology-based companies in China.

The rest of the paper is structured as follows. First, we provide a brief overview of the core concepts underlying our study, The TIC – firm competitive performance relationship and technology strategies – expressed as different technological innovation capabilities. We then provide the theoretical discussion of our research hypotheses. Next, we describe our research model, the measurement of research constructs and data analysis. Finally, we conclude with a discussion of the results, limitations, and intended contributions.

2. Literature review and research hypotheses

2.1. Technological innovation capability and firm competitive performance

The TIC – firm competitive performance relationship, has been widely discussed in different literature streams, such as *distinctive competencies* (Snow and Hrebiniak, 1980; Hitt and Ireland, 1985), *the resource based view of the firm* (Barney, 1991; Grant, 1991; Mahoney and Pandian, 1992; Peteraf, 1993), *the dynamic capabilities approach* (Prahalad and Hamel, 1990; Nelson, 1991; Lei et al., 1996; Teece et al., 1997) and *the knowledge – based view of the firm* (Kogut and Zanker, 1992; Grant, 1996a,b). Each of these four literature streams, either explicitly states or implies that a firm’s TIC can be a source of competitive advantage.

However, the relation between TIC and firm performance is more complex that what is generally assumed. Although many empirical studies have been done (Pakes, 1985; Jaffe, 1986; Henderson and Cockburn, 1994; McCutchen and Swamidass, 1996; Zahra, 1996; Deeds et al., 1997, 1998; DeCarolis and Deeds, 1999), little consensus has developed as to the exact relation between TIC and performance. A key reason of this is the multidimensionality of both concepts – TIC and performance.

Many researchers use R&D expenditures, patents or a combination of the two as indicators of firm's TIC (Pakes, 1985; Jaffe, 1986; McCutchen and Swamidass, 1996; DeCarolis and Deeds, 1999), others used measures such as citation counts (Deeds et al., 1997, 1998; DeCarolis and Deeds, 1999), absorptive capacity (Cohen & Levinthal, 1990). Besides, C.M. Yam et al. (2004) introduces a framework of TIC which has been used in many studies recently. In this framework, TIC is measured through seven dimensions – learning capability, R&D capability, resource allocation capability, manufacturing capability, marketing capability, organizing capability and strategic planning capability. Thus, we can say that each of these measured is an indicator of an element of the broad construct of TIC, but none are a comprehensive measure (Coombs & Bierly, 2006).

Firm performance can also be measured through different indicators (Clark & Fujimoto, 1991). The two major performance measures used are accounting measures and market value. Accounting measures include sales growth, return on sales (ROS), return on assets (ROA), and return on equity (ROE). Each measure of firm performance has advantages and disadvantages and each provides researchers with a perspective of success. The work of Coombs & Bierly (2006) investigates the relationship between TIC and firm performance by using multiple measures. The results show that the results may differ with different performance measures used.

2.2. Technology strategy expressed as TICs

The broad objective of technology strategy is to guide a firm in acquiring, developing and applying technology for competitive advantage. It is usually recognized now that a firm's technology strategy is influenced by the "technology regime" in which it operates (Mu and Lee, 2005). The regime is broadly defined by a combination of variables capturing industrial structure, nature of technical change and policy environment (Breschi, Malerba, and Orsenigo, 2000). A firm's technology strategy is also expected to serve its overall strategy in developing and exploiting firm specific advantages. In many theoretical work related to the technology strategy (Christensen, 1995), the firm's ability to develop different skills leading to technological innovation is highlighted by the TIC approach. The technology strategy is usually considered as a continuous knowledge accumulation process leading to new products and processes (Pavitt, 1990). In this perspective, we study the concept of technology strategy expressed as different TICs.

Firm's TIC is becoming a critical factor in its ability to meet the demands and challenges emerging from market globalization, technological advances, and intensification of knowledge (Lefebvre & Lefebvre, 1993). TIC can be broadly defined as a firm-specific collection of equipment, skills, knowleges, aptitudes and attitudes, which refers to the ability to operate, understand, change and create processes and products (Marcelle, 2005). Fransman (1984:10) defined TICs as all those abilities required to:

- ✓ Search and select the most appropriate technology;
- ✓ Master the selected technologies and successfully use them in production;
- ✓ Adapt those technologies to specific conditions of production and local demand;
- ✓ Achieve subsequent improvements through incremental improvement ;

- ✓ Search for more important innovation with the development of R&D facilities;
- ✓ Conduct basic research.

According to Fransman, the first four capabilities may not be necessarily presented in ascending order of complexity. However the last two make a fundamental distinction between those capabilities involved in ‘know-how’ and those involved in ‘know-why’. Bell and Pavitt (1993) extended the concept of technological capabilities to include resources required to manage the generation of technical change. These resources are accumulated and embodied in people (skills, knowledge and experience) and organizational systems. Another important concept related to TIC approach is that of *absorptive capacity*, which, according to Cohen and Levinthal (1990, p.128), is “an ability to recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends”. A growing number of studies have elaborated upon this concept. Zahra and George (2002) argues that absorptive capacity consists of four distinctive capacities:

- ✓ Acquisition – the search for new knowledge;
- ✓ Assimilation – understanding new knowledge;
- ✓ Transformation – seeing how new knowledge can be used in the context of the firm’s issues and exiting knowledge;
- ✓ Application – implementation of actions enabled by the new knowledge.

Clearly, these concepts can be applied to the approach of TIC, where we suggest that it refers to the ability to find and use technology to secure and sustain competitive performance. Since the 1980’s, it is well established that TIC can be differentiated along three types, that is investment capabilities, production capabilities and linkage capabilities (Fransman, 1986; Katz, 1987; Dahlman and Westphal, 1987; Lall, 1992; Marisa and J.Ortra, 2005; Chen and H., 2006). Our research model is based on these three kinds of TIC. Following section will give more details about these concepts and the formulation of our hypotheses.

2.3. *Research hypotheses*

2.3.1. *Investment Capabilities (IC) and firm competitive performance*

In the framework of Lall (1992), Investment Capabilities are defined as skills needed to identify, obtain technology for design, construction and commission of new products/ facilities. They determine the capital costs of the project, the appropriateness of the scale, technology and equipment selected. Investment capabilities have two elements: pre-investment and project execution. Under each element there are sub-elements to measure those ranging from routine to innovative activities. The spending that a firm’s make in different innovation activities (e.g. in-house R&D, purchasing license and patents etc.) show its commitment to the accumulation of knowledge that will give rise to new products/process or other kinds of innovation. The positive relation between firm’s investment in technological innovation and firm performance has been supported by various arguments: it enables firm to achieve greater capability to meet the demands of its changing domestic and international market (Zahra and George, 2002), thus give firm a good performance. It also enables firm to exploit the intangible technological assets, which can be beneficial to the learning process (Xie, 2004). Considering these ideas, we propose

the following hypothesis:

H1: The greater the investment in technological innovation made by the firm, the better its competitive performance.

2.3.2. Production Capabilities (PC) and firm competitive performance

Production Capabilities influence the productivity of labor and capital as well as efficiency in material and energy used. They have three elements: process engineering, product engineering and industrial engineering. Process engineering includes necessary activities for production. Product engineering contains activities required to produce products or improve product specifications, such as assimilation of product design, improvement in product quality, and basic research. Industrial engineering involves monitoring and control functions for process and product engineering. So technological production capabilities include all the skills related to the handling of these three engineering – process, product and industrial, along with supervision functions associated with production process (Lall, 1992). These production capabilities, together with R&D, are essential to the firm's technology development (Bell and Pavitt, 1993). The positive relation between the firm's ability in production and its performance is supported in the most literature work. Zahra and Covin (1994) indicates that a firm's superior capabilities in product development do have a positive influence on firm performance. In view of these ideas, the second hypothesis is proposed as following:

H2: The greater the accumulation of the firm's production capabilities related to innovation, the better its competitive performance.

2.3.3. Linkage Capabilities (LC) and firm competitive performance

Innovation cannot be regarded purely as an internal matter as firms' external linkages or networks may also play a potentially important role (Kleinknecht and Reijnen, 1992; Love and Roper, 1999; Bougrain and Haudeville, 2002 ; Caloghiron et al., 2002). External linkages may increase a firm's ability to appropriate returns from innovation (Gemser and Wijnberg, 1995; Linnarsson and Werr, 2004). Also, Powell (1998) argues that external linkages may help by stimulating creativity, reducing risk, accelerating or upgrading the quality of the innovations made, and signaling the quality of firms' innovation activities. Linkages within the economy involve abilities to organize procurement of goods and services, knowledge and technology transfer with suppliers and S&T links with research institutes, universities and other organizations. Firm's technological linkages capabilities can be defined here as the ability to transmit information, skills and technology, and to receive them from other departments of the company, clients, suppliers, consultants, technological institutions and so on. The role of external communication practices and networking as determinants of innovation has been emphasized in the literature. Souitaris (2001) indicates two categories of efforts that firm can make to establish channels of knowledge flow and linkages, that is scanning external information and cooperating with external organizations. The external knowledge that firms may seek access to can be categorized into two groups: knowledge from other firms and knowledge from

research institutions.

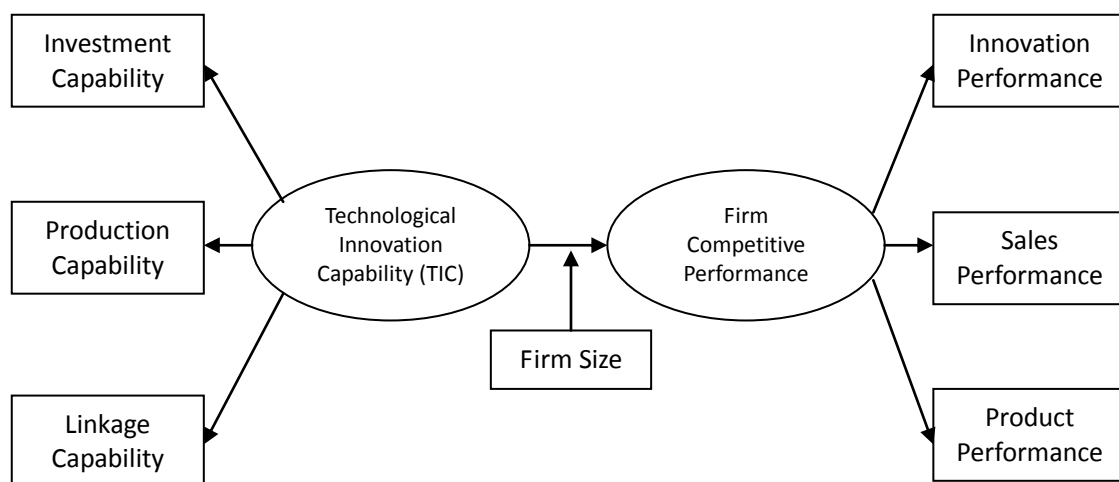
Some empirical research have found that participation in collaborations is indicative of an ability for interactive knowledge sharing that prove very beneficial for further exploitation of knowledge, and thus these linkages seem to promote innovativeness (Caloghirou et al., 2002). H.Love & Mansury (2007) suggest that external linkages, particularly with customers, suppliers and strategic alliances, significantly enhance innovation performance. In view of these ideas, we put forward the following hypothesis:

H3: The greater the firm's linkage capabilities related to innovation, the better its competitive performance.

3. Measuring TICs and firm performance

To begin, a brief introduction of the research model is useful to explain the research as a whole. Figure 1 illustrates the proposed model for the study and the following sections describe briefly the research construct and their measurements.

Figure 1. TIC – Firm Competitive Performance framework



The following measures were constructed for the study's dependent, independent and control variables.

3.1. Measurement of Firm competitive performance

Accounting measures such as sales growth, return on sales, return on assets, and return on equity are commonly used performance indicators in a range of fields such as entrepreneurship (Chakravarty, 1986; Zahra, 1996; Zahra et al. 2000), corporate governance (Dalton et al., 1998), international management (Hitt et al., 1997), and technological capability (Franko, 1989 ; Morbey and Reithner, 1990). Although the

firm performance in financial terms is always the best indicator, firms would not easily reveal any confidential financial information and different firms might adopt varied accounting conventions in their inventory valuations, depreciation, and salaries computation. Alternate measures should be used to secure adequate responses (Yam et al., 2004). We therefore use three types of performance indicators in this study: innovation performance, sales performance and product performance. Those measures are widely adopted in different innovation studies (Fu, 1998; Evangelista et al., 2001; Wan et al., 2003; Guan and Ma, 2003).

- ✓ Innovation performance is measured in terms of the number of commercialized new products expressed as a percentage of all products in the company over the past three years.
- ✓ Sales performance is measured in terms of the average annual sales growth over the last three years.
- ✓ Product performance is measured through six dimensions: average concept-to-launch time, quality level, cost advantage, market competitiveness, unique technology characteristics and/or special product manufacturing process, price/function advantage. The managers were asked to evaluate the product competitiveness compared to the competitors in the same sector through these six dimensions on 7-point scale, ranging from (1) not at all competitive to (7) extremely competitive.

3.2. Measurement of TIC related to investment capability

The questionnaire asked managers about the average proportion of spending made in the different innovation activities to the firm's total sales during the last three years. The investment capability is measured by means of seven-point scales, where the scales are labeled as 1(<1%), 2 (1% - 3%), 3(3% - 5%), 4(5% - 7%), 5(7% - 10%), 6(10% - 20%), 7(>20%). These innovation activities are drawn upon the Oslo Manual (OCDE-Eurostat, 1997) to detect the technological investment capability, which consists of seven dimensions:

- a) purchasing of tangible technology, such as machinery and equipment;
- b) purchasing intangible technology, such as patent and licence;
- c) Conducting contracted R&D activities (sub-contracted R&D and joint R&D activities);
- d) In-house R&D;
- e) Knowledge depending, such as training, inviting experts from outside for problem solving, trials and experiments;
- f) Improvement of existing product and process technology.
- g) Marketing of new or improved products

3.3. Measurement of TIC related to production capability

In order to detect technological production capability, managers were asked in the questionnaire to assess their firm's production capability related to generating innovations compared to the competitors in the same sector on 7 point-scale, ranging from (1) very unsatisfactory to (7) very satisfactory. Those technological production capabilities are drawn upon the literature and adjusted after pre-testing with the academy and practical people. Finally, we utilize the following eight dimensions to measure production capability, they are:

- a) The improvement and adaptation of production process;
- b) The improvement of product;
- c) The design of changes to production organization or market need;
- d) The improvement of product quality;
- e) The imitation of technologies brought in by competitors;
- f) The imitation of innovation in products developed by competitors;
- g) The development of the firm's own technology (machinery, processes, etc.);
- h) The design of new products.

3.4. Measurement of TIC related to linkage capability

Managers were asked to assess the level of the impact of several links on firm's technological development. Linkage capability is also measured on 7 point-scale, where 7 indicated the highest level of influence and 1 the lowest level of influence. Those internal and external links are:

- a) R&D department with production department;
- b) R&D department with marketing department;
- c) External linkages with suppliers of equipment, materials, components, or software;
- d) External linkages with clients or customers;
- e) External linkages with competitors or other firms in the sector;
- f) External linkages with private consultancy organizations;
- g) External linkages with the universities or other higher education institutes;
- h) External linkages with the government research institutes.

3.5. Measurement of Control variable

Firm size is also included in our study as control variable along with previously mentioned variables. Firm size is measured through the number of employees in the company.

4. Conduct of an empirical survey

4.1. Sample profile

Research was conducted with the assistance of Suzhou Science and Technology Town (SSTT) and Shanghai Zhangjiang Technology Park. The questionnaire survey received responses from 231 firms. Of these firms, 215 questionnaires were usable. These are composed of 88 large firms (> 500 staff), 58 medium-size firms (100 < staff number < 500), 68 small firms (< 100 staff). The majority of respondent firms are domestic private firm (43.7%), then State-Owned Enterprise (SOEs) (23.3%), foreign Joint-Venture (10.2%), foreign company (14%) and public listed company (8.8%) .

Table 1: Staff number of the respondent firms

	Frequency	Percent	Valid Percent	Cumulative Percent
< 50	47	21.9	21.9	21.9
50 - 99	21	9.8	9.8	31.6
100 - 249	42	19.5	19.5	51.2
250 - 499	17	7.9	7.9	59.1
500 - 999	30	14.0	14.0	73.0
> 1000	58	27.0	27.0	100.0
Total	215	100.0	100.0	

Table 2: Ownership of the respondent firms

	Frequency	Percent	Valid Percent	Cumulative Percent
Domestic private firm	94	43.7	43.7	43.7
State-Owned Enterprise	50	23.3	23.3	67.0
Foreign Joint-Venture	22	10.2	10.2	77.2
Foreign company	30	14.0	14.0	91.2
Public listed company	19	8.8	8.8	100.0
Total	215	100.0	100.0	

4.2. Principal components analysis

The factor analysis was firstly used to explore the existence of underlying dimensions to the data for each of the research constructs. Table 3 shows the results of factor analysis of investment capability for technological innovation. The principal components analysis with the Varimax rotation method revealed three factors accounting for 67% of the total variance. The selection of three factors was based on rule of Kaiser, in combination with the Screen-test. The first of the three factor was interpreted as investment in non R&D activities (IC1), which consisted of intensity of depending in improvement of existing technology, marketing of new products and training of staff. The second factor can be interpreted as investment in external

technology (IC2), which consisted of intensity of depending in patent, licence acquisition, contracted R&D and machinery acquisition. The last factor was associated with intensity of depending in in-house R&D, which can be labeled as investment in in-house R&D (IC3). Then the factors scores related to these three factors were also calculated for use in the subsequent analysis.

Table 3: Principal components analysis of investment capability

Factor loadings			
	IC1 Investment in non R&D activities	IC2 Investment in external technology	IC3 Investment in in-house R&D
Intensity of improvement of existing technology (ICf)	.859	.098	.098
Intensity of marketing of new products (ICg)	.834	.061	.147
Intensity of training of staff (ICe)	.623	.333	-.259
Intensity of Patent, licence acquisition (ICb)	.080	.852	-.099
Intensity of Contracted R&D (ICc)	.382	.618	.098
Intensity of machinery acquisition (ICa)	.029	.586	.368
Intensity of In-house R&D (ICd)	.078	.079	.918
Percentage of variance explained	36.039	16.193	14.337

Kaiser-Meyer-Olkin sample adequacy measurement: 0.690. Bartlett's sphericity test: 265.455. Significance: 0.000.

Table 4 shows the results of factor analysis of production capability for technological innovation. The dimension of "*the imitation of technologies brought in by competitors (PCe)*" was deleted, as the correlation coefficient of this item on the anti-image matrix was less than 0.50. After the elimination of PCe, we obtained a KMO value of 0.711, higher than the value before purification (0.665), which indicated an improved ability of data to be factored. Then the PCA with Varimax rotation method revealed three factors which explained 76.62% of total variance. The rule of Kaiser and Screen test confirmed the choice of three factors. The first factor was labeled as exploitative capabilities, consisted of the capabilities related to product improvement, design changes to production organization or market need, improvement of production process and product quality. The second factor, comprising the capabilities of development firm's own technology and design of new products, was labeled as explorative capabilities. The third factor was related to the capability of imitation in products developed by competitors, so we interpreted it as duplicative capabilities. Factor cores were calculated for use in further analysis.

Table 4: Principal components analysis of production capability

Factor loadings			
	PC1 Exploitative capabilities	PC2 Explorative capabilities	PC3 Duplicative capabilities
Product improvement (PCb)	.841	.107	-.019
Design changes to production organization or market need (PCc)	.775	.266	.226

Improvement and adaptation of production process (PCa)	.770	.036	-.062
The improvement of product quality (PCd)	.684	.242	.200
Development of firm's own technology (PCg)	.175	.934	-.061
Design of new products (PCh)	.180	.917	.148
Imitation of innovation in products developed by competitors (PCf)	.088	.043	.973

Kaiser-Meyer-Olkin sample adequacy measurement: 0.711. Bartlett's sphericity test: 553. 932. Significance: 0.000.

Table 5 shows the results of factor analysis of linkage capability. Two items “*the linkage with the private consultancy organization (LCf)*” and “*the linkage with the universities or the higher education institutions (LCg)*” were deleted, as the correlation coefficient of these two items on the anti-image matrix were less than 0.50. After the elimination of LCf and LCg, we obtained a KMO value of 0.629, higher than the value before purification (0.586), which indicated an improved ability of data to be factored. The subsequent PCA with Varimax rotation led to the extraction of three factors, which explained of 70.898% of total variance. The first factor, defined as external commercial linkages (LC1), represented the firm's external link with its clients, suppliers and other firms in the sector. The second factor, defined as internal linkages, consisted of the firm's internal link among R&D department, marketing department and production department. The third factor was interpreted as linkages with public research institutes, as it contained only one item. Factor cores were also calculated for use in further analysis.

Table 5: Principal components analysis of linkage capability

Factor loadings			
	LC1 External Commercial Linkages	LC2 Internal linkages	LC3 Linkages with public research institutes
The client or customers (LCd)	.827	.078	.175
The suppliers of equipment, materials, components, or software (LCc)	.825	.010	-.091
The competitors or other firms in the sector (LCe)	.578	.486	.197
R&D department with marketing department (LCb)	-.027	.915	.024
R&D department with production department (LCa)	.418	.459	.232
The government research institutes (LCh)	.070	.104	.970

Kaiser-Meyer-Olkin sample adequacy measurement: 0.692. Bartlett's sphericity test: 211. 691. Significance: 0.000.

Besides, the scale reliability of product performance (six items) was checked using Cronbach alpha value (0.781), which implied all the scales internally consistent.

4.3. Regression analysis

The multiple linear regression analysis was used to test our research hypotheses, where the firm competitive performance (three indicators) was introduced as dependent variable. TICs related to investment (three factors), production (three

factors) and linkage (three factors) were introduced as independent variables in our model. The control variable, measured by the firm size was also included. Table 6 shows the correlation matrix of variables used in the regression analysis. The analysis of variance inflation factors (VIF) and tolerance value allowed us to think that there is no multi-collinearity. The results of the multiple linear regression are presented in table 7. However, it is necessary, before concluding on the results, to analyze the residuals of regression. The review of the charts of residual distribution allowed us to ensure the residuals are independent of the dependant variable.

Table 6: Correlation matrix of variables used in the regression analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.IC1	1												
2.IC2	.000	1											
3.IC3	.000	.000	1										
4.PC1	-.031	.176**	.100	1									
5.PC2	.150*	.219**	.165*	.000	1								
6.PC3	.148*	.088	-.113	.000	.000	1							
7.LC1	.182**	-.045	.068	.342**	.061	.021	1						
8.LC2	.060	.128	.016	.352**	.166*	.020	.000	1					
9.LC3	.169*	.233**	.245**	.187**	.148*	.026	.000	.000	1				
10.Firm size	.006	.181**	-.001	.243**	.362**	.082	-.061	.186**	.061	1			
11.Innovation performance	.170*	.459**	.074	.263**	.209**	.154*	.076	.326**	.229**	.161*	1		
12.Sales performance	.086	.280**	-.003	.279**	.241**	.374**	.047	.186**	.176**	.370**	.447**	1	
13.Product Performance	.201**	.263**	.129	.389**	.250**	.255**	.219**	.351**	.164*	.361**	.541**	.507**	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 7: Regression analysis of TIC and Firm Competitive Performance

	Dependent variables		
	Innovation performance Beta (Mode 1)	Sales performance Beta (Mode 2)	Product competitiveness Beta (Mode 3)
Investment capability			
IC1: Investment in non R&D activities	0.116*	0.010	0.123**
IC2: Investment in external technology	0.042	-0.020	0.107*
IC3: Investment in in-house R&D	0.376***	0.130**	0.134**
Production capability			
PC1: Exploitative capabilities	0.088	0.181**	0.179***
PC2: Explorative capabilities	0.050	0.117*	0.57**
PC3: Duplicative capabilities	0.101*	0.338***	0.211***
Linkage capability			
LC1: External commercial linkages	0.034	0.010	0.140**
LC2: Internal links	0.229***	0.038	0.207***

LC3: Linkages with public research institutes	0.085	0.075	0.25**
Firm Size	-0.001	0.220***	0.223***
R ²	0.341	0.586	0.399
R ² Adjusted	0.309	0.344	0.37
F	10.553***	10.685***	13.562***

*Relation significant at level 0.1. ** Relation significant at level 0.05. *** Relation significant at level 0.01.

5. Results and discussion

In mode 1, where the innovation performance was considered as dependent variable, the overall regression equation was statistically significant ($F=10.685$, $P<0.01$). The independent and control variables incorporated in the model explained 30.9% of the variance in firm innovation performance. Four capabilities among nine showed a positive and significant relationship on innovation performance. In mode 2 (sales performance), the independent and control variables incorporated in the model explained 34.4% of the variance in firm sales performance ($F=13.569$, $P<0.01$). When the product performance was incorporated as dependent variable, the independent and control variable explained 37% of the variance in firm product performance ($F=10.553$, $P<0.01$). So the three regression equations were statistically significant.

Concerning the first hypothesis, the results of regression analysis in table7 shows that investment in non R&D activities has impact on innovation performance ($\beta=0.116$, $P<0.1$), product competitiveness ($\beta=0.123$, $P<0.01$), but not on the sales performance. Investment in external technology only has impact on product competitiveness ($\beta=0.107$, $P<0.1$). Investment in in-house R&D has impact on all of the three performance indicators. An important remark is that all these three factors related to the investment capabilities are proved significantly to have positive relationship with firm product performance. Hence, devoting investment in in-house R&D, external technology purchasing and non R&D activities contributes better firm product competitiveness. However, that's not true for the other two performance indicators. For instance, investment in non R&D activities proved to be positive, but not significant to the sales performance. Investment in external technology even shows negative influence on the firm sales performance. This could be interpreted in terms of its non-distinctive character when determining sales success. Concerning innovation performance, investment in in-house R&D and non R&D activities are justified to have contributed to the better innovation performance.

Besides, another important result deriving from this study is that investment in in-house R&D contributes better innovation performance, better sales performance and better product performance in Chinese technology-based firms. As Chen & Qu (2003) suggested, in-house R&D not only generates innovations, but also enable firms to assimilate external technological knowledge better, then to achieve better innovation performance, product competitiveness and then sales performance. So the results allow us to point out the importance of depending in in-house R&D and

devoting resources to some on R&D activities (e.g. technological training, improvement of existing product and process, marketing of new or improved products) in Chinese technology-based firms should be highlighted.

As far as the influence of production capability on firm performance is concerned (Hypothesis 2). The result shows that the exploitative capabilities have positive relationship with sales performance ($\beta=0.181$, $P<0.05$) and product performance ($\beta=0.179$, $P<0.01$), but not innovation performance. Explorative capabilities have been proved significantly to have positive relationship with sales performance ($\beta=0.117$, $P<0.1$) and product performance ($\beta=0.57$, $P<0.05$), but not innovation performance. Duplicative capabilities have impact on all of the three performance indicators. In summary, all the three production capabilities – exploitative, explorative and duplicative based are justified to have impact on product performance and sales performance. However, only the duplicative-based capabilities are proved to have effect on the innovation performance. In this respect, the importance of duplicative capability is highlighted in determining the innovation performance of Chinese technology-based firms. That's an interesting issue that deserves further research.

The third hypothesis referred to the impact of linkage capability on firm performance. The result shows that external commercial linkage capabilities has impact on product performance ($\beta=0.14$, $P<0.05$), but not innovation and sales performance. Internal linkage capabilities has impact on innovation performance ($\beta=0.229$, $P<0.01$) and product performance ($\beta=0.207$, $P<0.01$), but not sales performance. Linkage with public research institutes has impact on the product performance ($\beta=0.25$, $P<0.05$), but not innovation performance and sales performance.

The results also show that the firm internal links and external linkages with economy do have positive influence on firm performance. More specifically, the greater the firm co-operate within its different departments, and with its customers, suppliers, consultancy firms and public research institutes, better its product performance. However, the effects of the different linkages capability on sales performance and innovation performance have not totally been proved. For instance, the external commercial linkages proved to be positive, but not significant to the innovation performance and sales performance. One possible explanation for these results can be explained that a firm's co-operate with its clients, suppliers and other firms in the would be conceived as an activity that does not have distinctive character to contribute to some performance indicator, like innovation and sales performance.

6. Conclusions

The role of different technological strategies on a firm's competitiveness performance has received lots of attention in both academic and real business world. However, exiting literature relies heavily on case studies, anecdotes, and companies' reports, with little solid empirical findings. Given the most research work in technological

innovation in China have been concentrating at the national level or industrial level, this study investigates the link between the different technology strategies, expressed in terms of investment capabilities, production capabilities and linkages capabilities and three competitive performance based on a survey of 215 Chinese firms.

However, the results obtained in this study should be considered tentative rather than definitive. Some sample characteristic limits the generalization of the research results. The data in this study is obtained from the manager and firm itself is often not the best judge on its own performance. We can strengthen the methodology by using other sources, however, those kind of information are not always available in China, although Chinese officials have become more and more open with respect to information in recent year.

In the future research, the firm ownership can be incorporated in the research model to identify if the results differ with different corporate ownerships. Besides, the study of comparative evaluations of technological capability and firm performance in different sector deserved further research, as the relevance of technological capabilities for firm performance may be differ in industries with other accumulation patterns. The comparative studies in terms of technology strategy with other emerging countries, such Brazil, Russia and India can be also investigated in the future research.

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