How technological capability influences business performance

An integrated framework based on the contingency approach

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Abstract

Purpose – This study seeks to address three research questions: how technology capability impact business performance? Does the linkage between technology capability and business performance depend on specific contexts? Why do some high-tech firms of strong technological capability fail?

Design/methodology/approach – The paper draws on various theoretical perspectives to develop hypotheses that propose a direct relationship between technological capability and business performance (both new product development and overall business performance), the mediating role of customer value, the possible moderating effects of business environment and other important contingent factors such as learning orientation. A conceptual framework is devised and tested that examines these relationships in general and in various contexts, which is believed more important and useful for firms to manage their technological capability more effectively.

Findings – Findings from high-tech firms in China confirm the validity of the framework and afford various insights on the role of various contingent factors in the proposed relationships.

Originality/value – The paper provides a framework that examines companies' technological capability relationships.

Keywords Business performance, Learning, China

Paper type Research paper

1. Introduction

The resource-based view (RBV) of a firm asserts that the firm gain and sustain competitive advantage by deploying valuable resources and capabilities that are inelastic in supply (Peteraf, 1993; Wernerfelt, 1984). Up to now, a number of researchers

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have extended the theory's concepts, linking it to industry conditions and to innovation (Amit and Schoemaker, 1993; Mahoney and Pandian, 1992; Peteraf, 1993; Teece *et al.*, 1997) and witness that superior business performance is always derived from the possession of unique and difficult-to-imitate skills, knowledge, resources, assets or capabilities.

However, the lack of development of empirical tests was disappointing and systematic falsification remains very difficult (Hoopes *et al.*, 2003) although there have been continuing calls for empirical tests of this central resource-based theory since 1980s. Many scholars argue that the theory is essentially a tautology and criticize it for lack of empirical grounding (Mosakowski and McKelvey, 1997; Priem and Butler, 2001a, b; Williamson, 1999). Particularly, most of prior research has implicitly assumed that more resources and stronger capabilities are usually better to improve business performance. The consideration of exogenous factors usually has been absent from RBV literature with a few exceptions published recently (Aragon-Correa and Sharma, 2003; Barney, 2001a; Priem and Butler 2001a, b). Scholars lack a general theory to explain how characteristics of business environment, will affect dynamic capability and its impacts on business performance. However, the efficacy of dynamic capability varies with market dynamism and business environment affects dynamic capability and its impact on business performance in practice. Therefore, proponents of RBV have recently called for an inclusion of a contingency perspective in assessments of the competitive value of organizational resources and capabilities (Aragon-Correa and Sharma, 2003; Barney, 2001a; Priem and Butler 2001a, b) and strongly suggested a more expansive discussion of sustained differences among firms and thereby develop a broad theory of competitive heterogeneity (Hoopes *et al.*, 2003). Strategic researchers have included certain variables to examine the linkage in specific industry context in recent empirical studies (Brush and Artz, 1999; Maijoor and van Witteloostuijn, 1996; Miller and Shamsie, 1999; Zajac *et al.*, 2000). Most of these limited empirical studies examine the direct impact of unique capability on business performance and do not consistently capture the dynamic nature of competition in today's customer-centered era (Tuominen *et al.*, 2004). However, firms compete not on the basis of unique resources and capabilities, but on the basis of whether their resources and capabilities can be employed to meet customer needs. In other words, the value of a resource derives from its application in product markets and it traces back from the ultimate satisfaction of customer needs (Peteraf and Bergen, 2003). This implies that customer value may play a mediating role in the relationship between technological capability and business performance. However, none of the studies mentioned above test such a mediating effect. Furthermore, the very limited empirical studies of a contingent RBV have been conducted mainly within well-established market economies. In theory development and testing, however, these findings cannot be taken for granted excluding decisive influences of the context to which they may be applied. So does specific research on technological capability. As a matter of fact, there is a strong need to examine technological capability in order for an in-depth understanding of how firms with similar level of technological capability may have different performance level.

This paper bridges the research gaps by focusing on technological capability and examining the actual link between technological capability and business performance based on a contingent perspective of RBV. Specifically, the goals and potential contributions of our research to literature of technology strategy and RBV are fourfold. First, this paper extends resource-based theory into a new area of application, broadens the RBV's range and strengthens its position as the dominant explanation of inter-firm performance differences by developing a contingent RBV through integrating traditional RBV with the contingent perspective (Helfat and Peteraf, 2003). We argue that technological capability plays a critical role in competitive strategy for superior business performance but such an impact depends on the characteristics of business environment. Second, we examine, from a contingent perspective, how differentiated learning orientation may impact the influence of technological capability on business performance, and explain why two firms with similar technological capabilities may achieve different levels of business performance in front of similar environment. Third, we examine the mediated role of customer value in the relationship between technological capability and business performance, which may provide valuable suggestions for firms to strengthen their technological capability by keeping a dynamic fit between its technological capability and customers' needs. Fourth, our conceptual framework is empirically tested with evidence from high-tech firms in China, one of the biggest emerging markets in the world. Such an empirical analysis will not only help to overcome the limitations of the RBV, but also reinforce attempts to generalize the resource-based view of strategic management and marketing in a transitional economy.

We organize this paper as follows. We outline the framework for investigating the relationships among technological capability, learning orientation, environmental turbulence, customer value and business performance based on the moderated and mediated RBV, organizational learning theory and the new product literature in the next section, and then we explain the research method. Following that, we elaborate the empirical analysis using partial least square (PLS) method based on data collected from 248 high-tech firms. The paper concludes by discussing implications for strategic theory and technology management practices, identifying limitations of the study and providing directions for future research.

2. The conceptual framework and hypotheses

In today's customer-centered hypercompetitive environments, customers are characterized by choice seeking, demanding, knowledgeable, and the balance of power has shifted from firms to value seeking customers. Thus, managing technological capability for superior business performance by way of satisfying customer needs is even more critical to all firms. Only progressive firms that create maximum value for customers by deploying effectively their technological capability will survive and thrive.

The conceptual framework in Figure 1, is derived from the literature on the RBV, dynamic capabilities and organizational learning (Amit and Schoemaker, 1993; Henderson and Cockburn, 1994; King and Zeithaml, 2001; Mahoney and Pandian, 1992; Peteraf, 1993; Teece *et al.*, 1997; Wernerfelt, 1984). The framework demonstrates the manner in which technological capability influences business performance. First, by creating and delivering superior customer value, technological capability enables a firm to meet the demand of customers or even delight customers. Given the possibility that contextual characteristics may influence the link between technological capability and business performance, we draw on strategy literature and identify two kinds of moderating factors: environmental turbulence (both technological and market turbulence) and learning orientation. A firm committed to learning is likely to manage more effectively state-of-the-art knowledge and skills, which leads to the strengthened impact of technological capability.

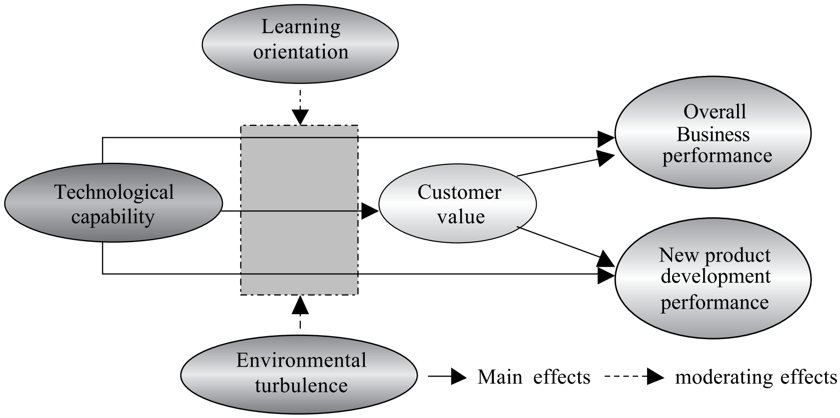

Figure 1.
The conceptual framework and proposed relationships

2.1 Technological capability and business performance
Technological capability refers to the ability to develop and design new products and processes and upgrade knowledge about the physical world in unique ways, thus transforming this knowledge into designs and instructions for the creation of desired outcomes. So they are not only the mastery of technological capabilities, but also the capabilities to deploy and expand the full implications of core competencies, combine various streams of technologies and mobilize technological resources effectively across firms (Kumiko, 1994; McGrath *et al.*, 1995; Torkkeli and Tuominen, 2002; Walsh and Linton, 2002; Afuah, 2002; Wang and Lo, 2004b). More concretely, technological capability is a set of pieces of knowledge that includes both practical and theoretical know-how, methods, procedures, experience and physical devices and equipment. It also represents the superior and heterogeneous technical assets of a firm and is closely related to product technologies, design technologies, process technologies and information technologies.

Furthermore, technological capability requires a deep understanding of scientific principles, as well as the ability to generate new knowledge, while being different from science in that they are usually implicit in experiences and skills (Wheelwright and Clark, 1992; Hayes *et al.*, 1988; Kumiko, 1994; Torkkeli and Tuominen, 2002; Fowler *et al.*, 2000; Afuah, 2002). Technological capability, in particular, represents an important potential source of competitive advantage and superior performance in technologically competitive markets (Nelson and Winter, 1982; Tyler, 2001). In addition, technological capability helps to increase a firm's ability to recognize and apply new external knowledge to continue the competence development, which may result in superior performance. Besides, superior technological capability usually enable firms to create and deliver innovative products or service in innovative ways that customers may value, and thus determine both the overall and new product development performance of a firm. As a matter of fact, the role of capability in building advantage has been well documented in the literature on the RBV (Barney, 2001a, b; Peteraf and Bergen, 2003) and the dynamic capability view. A central premise of RBV is that rival firms compete on resources and capabilities (Amit and Schoemaker, 1993; Barney, 1991; Collis and Montgomery, 1990; Dierickx and Cool, 1989; Wernerfelt, 1984), and suggests that superior resources and capabilities enhance business performance (Barney, 1991). For example, empirically, a variety of studies has shown that greater commitment to R&D investment on a persistent basis leads to the development of knowledge-based learning, which is used to improve both accounting-based and market-based measures of business performance (Bharadwaj *et al.*, 1999; Blundell *et al.*, 1999; Yeoh and Roth, 1999). Technological capability, in this regard, can be considered as core capability that provides firms with the means to develop and sell products and services that are valued by targeted customers, and manage customer relationship more effectively. However, research findings are mixed. For example, in a meta-analysis of 76 studies (Szymanski *et al.*, 1993), the positive impact of R&D strength is not substantiated. The ambivalent results from previous research make it more worthwhile to address the issue. Therefore, as most related studies, we can present the following hypothesis:

H1.1. Technological capability affects positively overall business performance.

H1.2. Technological capability affects positively new product development performance.

2.2 Mediating role of customer value

Researchers believe that the key to achieving superior business performance is to gain and hold a competitive advantage by developing unique capabilities (Day, 1994). To be sustainable, these capabilities must be rare, valuable, difficult to imitate or substitute, and should support the organization's business strategy (Barney, 1991; Day, 1994; Day, 1988). However, firms may tends to emphasize some of these attributes while overlook others such as "valuable". This tendency is typical for high-tech firms in China and senior managers believe that firms may achieve competitive advantages when they accumulate rare and inimitable technological resources and capabilities. They believe they will win the competition as long as they have superior technological capability due to the large market potential and the rapid growth rate. Such a tend that overemphasizes the strategic role of technological capability while overlooking other possible influential factors or attributes mentioned above is both controversial and arguable since there is little empirical evidence directly relevant to the issue. On the contrary of what RBV argues that superior strategic positions of a firm derive from unique bundle of resources and capabilities (Barney, 1991, 1986; Henderson and Cockburn, 1994; Miller and Shamsie, 1996; Peteraf, 1993; Wernerfelt, 1984), recent evidence shows that this is not necessarily true.

What's even worse is that the precise meaning of these terms (i.e. attributes), however, remains unresolved. For example, Barney (1991) defines "value" implicitly, according to whether capabilities enable a firm to respond to environmental threats or opportunities. By nature, "value" is a demand-side concept and the demand for resources is derived from the demand for final products. This implies that customers of final products determine the market value of resources and capabilities used. The utility or value of a resource and capability depends upon its utility in terms of satisfying a given set of customer needs by way of creating and delivering superior customer value in a cost-effective and rapid-responsive way (Peteraf and Bergen, 2003). Furthermore, in the typical value-price-cost (VPC) framework, a firm that produces the largest difference between value and cost has an advantage over rivals (Hoopes *et al.*, 2003; Postrel, 2002). A firm can either attract buyers due to the better surplus its product offers (VP) or make a higher profit (PC) or both. This means that simply having costly to imitate resources and capabilities does not necessarily produce competitive advantages, and a resource or capability is valuable only when it increases the difference between a firm's value and cost (VC) compared to rivals in competition (Barney, 1986). This implies that resources and capabilities do not exclusively determine what a firm can do and how well a firm can do it. Winners in the global marketplace are firms that demonstrate timely responsiveness, and rapid and flexible product innovation (Teece *et al.*, 1997) and delivery of superior customer value.

Superior customer value means continually creating business experiences that exceed customer expectations and thus constitutes the strategic drivers of business performance and firms can utilize it to differentiate themselves from the pack in the minds of customers. Based on extant literature, value may be best defined from the customers' perspective as a tradeoff between the benefits received from the offer and the sacrifices to obtain it (e.g. costs, stress, time, effort, inconvenience, etc.) (Slater, 1997; Woodruff, 1997). Thus each transaction is evaluated according to dissatisfaction, satisfaction, or high satisfaction experience in terms of the value received. As argued by Peteraf and Bergen (2003), the value of a resource derives from its application in product markets. It traces back from the ultimate meeting of customer needs. However, what drives consumer choice is not simply whether or not a product can meet a given need, but how well it can do so. Degree of satisfaction matters. With strong technological capability that has the potential to create and deliver superior customer value, firms may develop and launch products and services that bring more customer value, understand customer choices and preferences quite well and timely, increase competitive options, avoid price wars, improve service quality, strengthen communications, focus on what is meaningful to customers, and develop strong customer relationships. Therefore, by linking technological capability and business performance with customer value, this paper adds precision to the meaning of capability "value" in relation to competitive advantage by tracing the use and value of capabilities to the satisfaction of customer needs. Thus we can present the following hypotheses:

H2. Technological capability relates positively with customer value.

H3.1. Customer value relates positively with overall business performance.

H3.2. Customer value relates positively with new product development performance.

2.3 Contingent factors for superior business performance

Although technological capability is believed to contribute to superior business performance, building unique and stronger technological capability means an increment in business costs. Therefore, it is of strategic significance to know in which contingent contexts firms need to invest heavily in technological capability building process and when the impact of technological capability is more important to make sure the benefits obtained necessarily exceeding the costs due to heavy investment. For example, if environmental turbulence does moderate the effects of technological capability on business performance, a firm should pay great effort in achieving superior performance in a more cost effective manner by seeking the appropriate level of technological capability that matches the level of environment turbulence.

2.3.1 Environmental turbulence and its moderating role. According to resource dependence theory, the environment is perceived, interpreted and evaluated by human actors in organizations. Managers' perceptions become their reality, which makes environmental conditions important to the extent that they are perceived by managers and always result in distinct managerial actions (Daft, 1992; Hall, 1991). For example, Burns and Stalker (1994) argue that the basic information-gathering activities required for successful innovation differ in emphasis according to the level of perceived environmental uncertainty. Similarly, the capability required to achieve superior performance may also be contingent on the level of environmental turbulence. In fact, the impact of rapid technological change coupled with radical market changes has become increasingly evident in high-tech firms.

As suggested by the RBV, various factors external and internal to a firm can neutralize or dissipate a resource's comparative advantage (Barney, 1991; Peteraf, 1993; Reed and Defillippi, 1990; Eisenhardt and Martin, 2000). For example, a firm may fail to modify its resources in response to a change in the technologically turbulent environment. As a result, a capability or resource that was once an asset can become a liability if it is no longer appropriate. Furthermore, Leonard-Barton (1992) contends that core capabilities can become core rigidities in the face of the changing technological environments. In addition, the contingent theory argues that business performance is a result of the proper alignment of organization design variables with exogenous context variables (Burns and Stalker, 1994; Lawrence and Lorsch, 1967). Recent empirical evidence also shows that patterns of effective capability vary with market dynamism or a competitive environment (Brush and Artz, 1999; Eisenhardt and Martin, 2000; Nee, 1992). This may enable a dynamic fit with general business environment (Zajac *et al.*, 2000), and business environment affects the process of the development of dynamic capability and its impact on business performance. However, in high-tech firms of China, mangers have been extremely focusing on technological capability regardless of environment turbulence while giving less emphasis on other factors. In front of such a paradox, little empirical research, if any, can provide further evidence and little is known about how environment turbulence may moderate the impact of technological capability on business performance in a transitional economy.

In this paper, two kinds of environmental turbulence are emphasized and studied: technological and market turbulence (Boyd *et al.*, 1993; Milliken, 1987; Houston and Franklin, 1986). Technological turbulence refers to an individual's perception that he or she is unable to accurately predict or completely understand some aspects of the technological environment (Milliken, 1987). Organizations that work with nascent technologies that are undergoing rapid changes is much more likely to obtain a competitive advantage through technological innovation since the key challenge in such a context is not how to respond effectively to customer preferences, but how to keep up with the technological trends by leveraging, strengthening and upgrading technological capability. So only firms with stronger technological capability can create superior customer value, achieve superior performance and survive in technologically turbulent environments. By contrast, firms that work with stable (mature) technologies are relatively poorly positioned to leverage technological capability for superior performance, and must rely on other kinds of capability (e.g. marketing capability) to a greater extent. Following on from this, we present the following hypotheses:

H4.1. The greater the technological turbulence, the stronger the relationship between technological capability and overall business performance.

H4.2. The greater the technological turbulence, the stronger the relationship between technological capability and new product development performance.

H4.3. The greater the technological turbulence, the stronger the relationship between technological capability and customer value.

Market turbulence represents changes in the composition of customers and their preferences, and in competition intensity. Firms operating in high market turbulence are more likely to launch their products and services continually in order to successfully cater to customers' changing preferences and competitors' attacks. In environments characterized by market turbulence, the contribution of technological capability diminishes with the increasing market turbulence since the key challenge is not how to catch up with technological trends or achieve technological innovations when market turbulence is dominant. Heavy investment in technological capability at this time usually contributes less, if any, to the accurate forecasting and successful meeting of rapidly changing customer demands and may even constitute, somewhat, the waste of limited resources of a firm. Based on the above discussion, we present the following hypotheses:

H4.4. The greater the market turbulence, the weaker the relationship between technological capability and overall business performance.

H4.5. The greater the market turbulence, the weaker the relationship between technological capability and new product development performance.

H4.6. The greater the market turbulence, the weaker the relationship between technological capability and customer value.

2.3.2 Learning orientation and its moderating role. Thus, the relative role of a learning orientation and its impact on the organization provide a fertile arena for research.

Learning orientation fundamentally determines the learning propensity of a firm, the learning process it may adopt, the effectiveness, efficiency and sustainability of such learning processes, and thus determines the impact of technological capability. As our in-depth senior manager interviews show, with such a favorable learning orientation, it is not surprising for a firm to build and upgrade its technological capability and other capabilities relevant to information processing, communication, knowledge transfer, and the ability to develop trusting relationships and negotiation, which is the key to make sure the fitness between technological capability and environment turbulence. In this study, we tend to view learning orientation as a cultural construct reflected by a firm's knowledge-questioning values such as commitment to learning, shared vision and open-mindedness. The more a firm values learning, the more likely it is that learning will occur (Slater and Narver, 1994) and without a shared vision, learning by members of a firm is less likely to be meaningful (Verona, 1999). Furthermore, The rate of knowledge obsolescence is high in high-tech sectors. With open-mindedness, a firm is willing to question long-held assumptions about its mission, customers, capabilities, or strategy (Slater and Narver, 1995) and to pursue exploratory learning and discover unarticulated needs to be better able to adapt to shorter product life cycles through innovation (Kyriakopoulos and Moorman, 2004).

This may avoid focusing on articulated needs only and resulting in missed opportunities for radical innovation.

Learning orientation is also an organizational characteristic. Conceptualizing organizational characteristics as moderators is consistent with past research on learning (Sinkula, 1994) and with past research on the relationship between market orientation and performance (Gatignon and Xuereb, 1997). Learning orientation can also be viewed as the qualitative engine behind market orientation that prevents rigidity. If members of an organization have an enhanced learning orientation, they will not only gather and disseminate information about technological markets, but also constantly examine the quality of their interpretive and storage functions and the validity of the dominant logic that guides the entire process. Learning orientation helps to inspire employees to put in their maximum effort, develop an environment that encourages creativity and innovativeness, and manage the firm's financial and physical resources judiciously to create value. In addition, a strong learning orientation is likely to reduce an organization's reliance on market feedback as the only route to new product development. It is thus reasonable to expect that a firm which has been more learning-oriented will be able to leverage its technological capability to create more customer value and achieve superior performance as compared with a firm which has been less learning oriented. Therefore:

H5.1. Learning orientation positive moderates the relationship between technological capability and overall business performance.

H5.2. Learning orientation positive moderates the relationship between technological capability and new product development performance.

H5.3. Learning orientation positive moderates the relationship between technological capability and customer value.

3. Method

3.1 Sample and data collection

Our research design entailed a large-scale cross-sectional survey. The sampling population was constituted by high-tech firms in Shenzhen, Tianjin and Beijing of China. Several important reasons occur for selecting China, a country undergoing reforms from a centrally planning to a market economy. First, environmental dynamism in China is unprecedented, and the effect of environments may be more prominent in the development of customer orientation and marketing capability. The extreme complexity and dynamism means that firms must confront not only the challenges of new competition, but also collapsing capabilities (Li and Atuahene-Gima, 2001; Luo and Park, 2001). Second, China is an ideal site for testing the generalizability of western organizational and management theories since the institutional and market environment is much different from that in the Western economy (Batra, 1997; Deng and Dart, 1999; Deshpande and Farely, 2000; Shenkar and von Glinow, 1994). Given China's distinctive culture, economic and political systems, particularly its population and fast growing economy with an average of 9 percent of real GDP growth for the past 20 years and large market potential, social and managerial theories must explore their implications in China to be complete.

Technology management in high-tech firms may confront unique issues given high levels of uncertainty (Beard and Easingwood, 1996; Moriarty and Kosnik, 1989).

For instance, such firms may tend to introduce a new technology to market (Kerin *et al.*, 1996), and emphasize technology function and rapid new product development (Dugal and Schroeder, 1995; Marcus and Segal, 1989). In China, some managers believe that high-tech markets should be different from those in traditional industries in that marketing focus or customer value may be not important for high-tech firms. Such thinking is strengthened by product development literature concluding that the superior product will win the competition (Cooper, 1987; Kleinschmidt and Cooper, 1991). However, other studies provide evidence that customer expectations are probably more critical in high-tech markets since product attributes change rapidly leading to dynamic expectations (Bridges *et al.*, 1995). Therefore, the role of technological capability and its impact on performance of high-tech firms remain an unsolved problem.

A stratified sampling method was firstly used, and then a random sampling technique was applied to identify potential respondents based on a name list of high-tech firms from a business intelligence consulting firm and totally 400 firms were identified. We adopted the retrospective report method since it has been commonly used in studies strategic management, organizational research, and marketing (Bourgeois and Eisenhardt, 1988; Huber and Power, 1985; Li and Calantone, 1998; Sinkula *et al.*, 1997). To improve the reliability and validity of this method, we took several measures suggested by Huber and Power (1985) and Miller *et al.* (1997). Furthermore, confidentiality was also promised since Chinese managers provide reliable data with such assurance (Li and Atuahene-Gima, 2001). In addition, we chose CEO, president or vice-president of marketing as the key informants (John and Reve, 1982; Ritter and Gemnden, 2004; Seidler, 1974; Van Bruggen *et al.*, 2002). The quality of informants in terms of their self-reported knowledge about issues under study was examined (Connant *et al.*, 1990). We asked each informant to indicate on a ten-point scale his degree of knowledge in strategic and technology management issues. The means were 8.01 and two informants scoring 5 and below on this question were not included in final analysis. Besides, unlike all other variables measured on the seven-point scale, we measured overall business performance and new product development performance on a five-point scale, providing a psychological frame hindering common method bias (Podsakoff *et al.*, 2003). In addition, many previous studies have provided substantial evidence of supporting the reliability and validity of self-reported measures by key informants (Brush and Vanderwerf, 1992; Dess and Robinson, 1984; Spanos and Lioukas, 2001; Venkatraman and Ramanujam, 1986). Besides some effective measures taken to avoid any distorted self-reports and socially desirable answers suggested by Podsakoff and Organ (1986) and Harman's (1967) one-factor test was used and an seven-factor solution emerged, explaining 80.4 percent of the variance with no single factor explaining more than 20 percent of the variance. Thus common method variance is not a big problem. In sum, although other scholars, admittedly, object to subjective measures based on senior managers' perceptions (Aldrich, 1979; Dess and Robinson, 1984; Keats and Hitt, 1988; Lawless, 1989), we could argue that managerial perceptions shape to a very important extent the strategic behaviors and competences of a firm, which goes along with Chattopadhyay *et al.* (1999). In this sense, the use of self-reported measures might be justified, albeit not without potential problems.

Finally, 248 responses were considered valid, and were used for final analysis, resulting in a valid response rate of 62 percent. The final sample included such industries as computer-related products, electronics, electric equipment, telecommunications equipment, and pharmaceuticals. To examine non-response bias, multivariate analysis of variance was conducted to compare the possible differences in total assets, number of employees and R&D spending among both responding firms and non-responding firms. The results were not significant at the 99 percent confidence level, suggesting no significant difference between the two groups.

3.2 Measures

Based on the intensive literature review, totally 34 items were identified and retained on the basis of two panels of academic experts in related fields, two rounds of in-depth senior manager interviews, pre-testing and the pilot study. Specifically, we used ten items to measure technological capability in pre-test and pilot study (Danneels, 2002; Buzzell and Gale, 1987; Lapierre, 2000; Miyazaki, 1994; Dosi, 1984, 1988; Tyler, 2001; Danneels, 2002; Henderson and Cockburn, 1994; Spanos and Lioukas, 2001; Fowler *et al.*, 2000, etc.). Results of item-to-total score correlation and the effects of deleting items on Cronbach's α based on the pilot study data show that only nice items should be finally retained (Nunnally, 1978), which are shown in Table I. Respondents were asked to assess the customer value of their own firm relative to those of its major rivals or customers' desires in terms of four indicators (Day, 1994; Narver and Slater, 1990; Slater, 1997; Woodruff, 1997; Zeithaml, 1988; Wang *et al.*, 2004a). For environmental turbulence, eight items were adapted (Boyd *et al.*, 1993; Miller, 1987). However, our pilot study results show that only six items should be retained. For learning orientation, seven items were adapted with some modifications in wordings (Sinkula *et al.*, 1997; Baker and Sinkula, 1999). Finally, six items were retained based on exploratory factor analysis results. For overall business performance, variable selection was made originally using a combination of four items (Narver and Slater, 1990; Slater and Narver, 1994). Similarly, five items were adapted for new product development performance. Given the limitations of data availability and accessibility to generating objective performance assessments, perceptual performance was used since a high correlation has been found between objective and perceptual indicators (Dess and Beard, 1984; Venkatraman and Ramanujam, 1986). Furthermore, previous studies conclude that the relative comparability of perceptual measures may not be inferior to using objective data (Baker and Sinkula, 1999; Slater and Narver, 1995; Golden, 1992; Wang and Lo, 2004b). So the subjective measures are more suitable given the cross-sectional nature of our study.

4. Data analysis and structural equation modeling building

PLS-based variance analysis (Chin *et al.*, 2003; Wold, 1982) is gaining interest for its ability to model latent constructs uncontaminated by measurement error (Hair *et al.*, 1998; Fornell and Cha, 1994) under conditions of non-normality and small to medium sample sizes. Furthermore, in moderating effect testing, analysis of variance approaches fail to report effect size estimates, while the moderated regression analysis may have few significant terms, small effect sizes and low statistical power compared with the PLS method (Chin *et al.*, 2003). Therefore, in this paper, we adopted the PLS

Construct/items	Standardized loading	*t*-value
Technological capability (α = 0.90)		
We always make relatively heavy investment in R&D activities	0.74	20.27
We have accumulated stronger and various technological skills	0.77	21.93
On-job raining is provided frequently in our firm to improve the technical skills of employees	0.73	26.41
We are qualified to attract and motivate talented experts	0.65	14.54
We have the ability to accurately predict future technological trends	0.79	25.69
We are skillful in apply new technology to problem-solving	0.83	36.01
We are one of the leaders in our primary industry to establish and upgrade technology standards	0.76	23.14
We always lead technology innovation of the principal industry in which we operate	0.87	22.38
Compared with our major competitors, we have competitive and powerful technology strategy[a]		
We have strong capability to integrate external technological resources with in-house resources of our firm	0.80	20.71
Learning orientation (α = 0.82)		
The basic values of our firm include learning as the key to improvement	0.69	17.92
Learning in our firm is seen as a key commodity necessary to guarantee organizational survival	0.72	10.23
There is commonality of purpose in our firm	0.71	13.39
We realize that the usual way they perceive the market-space must be continually questioned	0.68	11.51
We are encouraged to create innovative ideas and learn new knowledge	0.84	12.42
Top Leadership believes in sharing its vision for the business unit with the lower levels[a]		
We have a well defined vision for the entire business unit	0.79	11.03
Customer value (α = 0.85)		
Overall, our offerings are value for money	0.76	26.67
Considering expenses and offerings they get, customers believe it is a right decision to transact with us	0.81	30.65
We always try to reduce the time and effort customers have to spend in the processes of obtaining and consuming our offerings	0.68	10.39
Taking the major competitors' offerings into consideration, our customers believe that our offerings are value for money	0.80	23.44
Market turbulence (α = 0.81)		
The level of market turbulence in external environment is extremely high	0.80	40.53
It is impossible to predict accurately the rapidly changing demands and tastes of consumers	0.85	51.69
Activities of major competitors are unpredictable and competition is very intense	0.83	45.04
New customers tend to have product-related needs different from those of our existing customers[a]		

(continued)

Table I.
Confirmatory factor analysis results based on PLS method

Construct/items	Standardized loading	t-value
Technological turbulence ($\alpha = 0.82$)		
The speed of technological changes in the principal industry in which our firm operate is fast	0.75	26.82
The technological changes in the principal industry in which we operate is unpredictable	0.83	36.05
The impact of new technology on business operations and competition is rather high	0.81	27.89
Technological changes provide big opportunities in our industry[a]		
Overall business performance e ($\alpha = 0.88$)		
With regard to your firm's main marketplace, how satisfied you are with the performance of your firm relative to your major, direct competitors in terms of:		
Profitability	0.74	18.92
Growth of market share	0.88	67.74
Cost effectiveness	0.86	32.14
Overall firm performance	0.80	27.49
New product development performance ($\alpha = 0.87$)		
With regard to your firm's main marketplace, how satisfied you are with the performance of your firm relative to your major, direct competitors in terms of:		
Growth of sales of new developed products in the past two years	0.82	28.07
Growth of profits from new developed products in the past two years	0.83	33.61
Growth of market share of new developed products in the past two years	0.74	15.44
We always integrate advanced knowledge into new products to meet the changing needs of customers	0.78	24.96
Our new developed products always bring targeted customers unique benefits	0.79	21.25

Note: [a] Indicates items that were deleted during the scale purification process

Table I.

method rather than the typical maximum likelihood (ML method) based covariance structure analysis (Bollen, 1989; Joreskog and Sorbom, 1993).

4.1 Measurement model

Following the two-step approach recommended by Anderson and Gerbing (1988), the adequacy of each multi-item scale in capturing its construct was assessed. First, the composite reliability for internal consistency is demonstrated, since values for all constructs are above the suggested threshold of 0.70, with a minimum of 0.81. Second, the standardized factor loadings for all items are above the suggested cut-off of 0.60 (Hatcher, 1994), with a minimum of 0.66, and all are significant with strong evidence of convergent validity. Table I shows the results from confirmatory factor analysis. Besides, the average variance extracted (AVE) of each construct is more than 0.50, which meets the criterion that a construct's AVE should be at least higher than

Table II.
Correlation matrix and descriptive statistics of measures with the square root of AVE

	Mean	SD	1	2	3	4	5	6	7
Technological capability	4.83	0.90	0.76						
Customer value	5.11	0.68	0.61**	0.77					
Learning orientation	5.47	0.81	0.45**	0.49**	0.72				
Market turbulence	4.09	1.00	0.17*	0.10	0.02	0.74			
Technological turbulence	4.83	1.03	−0.18*	−0.19*	−0.13	0.37**	0.79		
Overall business performance	3.93	0.86	0.53**	0.53**	0.36**	0.21*	−0.17*	0.80	
New product development performance	3.82	0.89	0.64**	0.60**	0.46**	0.13	−0.18*	−0.49**	0.79

Notes: *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level

50 percent to guarantee more valid variance explained than error in its measurement (Fornell and Cha, 1994; Fornell and Larcker, 1981).

Third, Table II shows that the square-root of AVE of any construct is higher than the correlations between it and all other construct in our model (Fornell and Cha, 1994; Fornell and Larcker, 1981). The smallest square root of AVE is learning orientation and the value is 0.72, while the biggest correlation coefficient is that between technological capability and new product development performance and the value is 0.64, which indicates strongly that all the constructs involved are both conceptually and empirically distinct from each other. Besides, R^2 of endogenous variables, i.e. customer value, overall business performance, new product development performance, is 0.46, 0.38, and 0.55, respectively (the first stage), implying good predictive power of our model.

4.2 Structural equation modeling building and hypotheses testing

Having established confidence in measurement model, we began to examine the main effects by building Model I. Traditional parametric tests are inappropriate in PLS method, so a bootstrapping method of sampling with replacement was used on the basis of 500 bootstrapping runs. Table III shows that the R^2 of overall business performance and new product development performance in the first stage (the main effects) is 0.38 and 0.55, respectively and the path coefficients of technology capability is 0.34 ($t = 4.78$) and 0.42(7.67), which are all statistically significant at the level of 0.001. This provides support for positive and direct main effects of technology capability on overall business performance (*H1.1*) and new product development performance (*H1.2*). Furthermore, Table III also shows that the R^2 of customer value is 0.46 and technological capability has a statistically significant effect on customer value (*H2*), this effect is strong and effect size is large (path coefficient is 0.38, $t = 8.72$). Similarly, we also find that customer value has statistically significant effects on overall business performance (path coefficient is 0.32 and $t = 4.46$) and new product development performance (path coefficient is 0.29 and $t = 3.70$). So *H3.1* and *H3.2* are strongly supported. This implies that customer value does mediate the effect on

Endogenous variables (path to)	Exogenous variable (path from)	Prediction	The first stage standardized parameters	*t*-Value	The second stage standardized parameters	*t*-value
Overall business performance	Technological capability	*H1.1*	0.34	4.78**		
New product development performance	Technological capability	*H1.2*	0.42	7.67**		
Customer value	Technological capability	*H2*	0.38	8.72**		
Overall business performance	Customer value	*H3.1*	0.32	4.46**		
New product development performance	Customer value	*H3.2*	0.29	3.70**		
Customer value	Technological turbulence		−0.19	4.53**		
Customer value	Market turbulence		0.11	1.47		
Customer value	Learning orientation		0.26	4.12**		
Overall business performance	Learning orientation		0.12	1.49		
New product development performance	Learning orientation		0.14	2.03		
Overall business performance	Technological turbulence		−0.12	1.83		
New product development performance	Technological turbulence		−0.09	1.90		
Overall business performance	Market turbulence		0.18	2.27		
New product development performance	Market turbulence		0.05	0.96		
Overall business performance	Technological capability X Technological turbulence	*H4.1*			0.18	1.89♀
New product development performance	Technological capability X Technological turbulence	*H4.2*			−0.00	0.01
Overall business performance	Technological capability X Market turbulence	*H4.4*			0.11	1.26

(*continued*)

Table III.
Results of PLS-based structural equation models

Endogenous variables (path to)	Exogenous variable (path from)	Prediction	The first stage standardized parameters	*t*-Value	The second stage standardized parameters	*t*-value
New product development performance	Technological capability X market turbulence	*H4.5*			−0.24	1.98*
Overall business performance	Technological capability X Learning orientation	*H5.1*			0.13	1.94♀
New product development performance	Technological capability X Learning orientation	*H5.2*			−0.01	0.07
Customer value	Technological capability X Technological turbulence	*H4.3*			0.07	0.67
Customer value	Technological capability X Market turbulence	*H4.6*			−0.29	2.01*
Customer value	Technological capability X Learning orientation	*H5.3*			0.04	0.27
R^2 *Customer value*			0.46 (Model I)		0.55 (Model I)	
Overall business performance			0.38 (Model II)		0.42 (Model II)	
New product development performance			0.55 (Model II)		0.60 (Model II)	

Notes: $^{*}p < 0.05$; $^{**}p < 0.001$; ♀$p < 0.10$

Table III.

technological capability on overall business performance and new product development performance. In order to provide more evidence to support this finding, another model is built with customer value and technological capability as exogenous variables impacting overall business performance and new product development performance directly, and R^2 of overall business performance and new product development performance decreases significant to 0.31 and 0.47, respectively.

Totally, two sets of models were developed in order to test the rest hypotheses: one set is for the moderating effects on technological capability and customer value, the other is for technological capability and overall business performance and new product development performance. Next we included the moderating variables in each set of models in addition to main effects in the first stage. As in regression analysis, the predictor and moderator variables were multiplied after standardization to obtain the interaction terms (Chin *et al.*, 2003). Results of models in the second stage can be found in Table III. The R^2 for overall business performance and new product development is about 0.42 and 0.60, respectively, and the R^2 for customer value is about 0.55. Then the overall effect size was calculated using the equation as follows (Cohen, 1988):

$$f^2 = \left[\frac{R^2(\text{Interaction}-\text{model}) - R^2(\text{Main}-\text{effects}-\text{model})}{[1 - R^2(\text{Interaction}-\text{model})]}\right]$$

As a result, we found that the overall effect size f^2 is about 0.20, 0.07 and 0.13, respectively for customer value, overall business performance and new product development performance. Generally, values of f^2 as 0.02, 0.15 and 0.35 have been suggested as small, moderate and large effects, respectively (Cohen, 1988). It should be noted, however, a small overall effect size f^2 does not necessarily imply an unimportant effect. Even a small interaction effects can be meaningful under extreme moderating conditions. Therefore, taking path coefficients into consideration, we are confident to declare the existence of moderating effects of environmental turbulence and learning orientation. Specifically, market turbulence negatively moderates the relationship between technological capability and customer value, and the path coefficient is -0.29 ($t = 2.01$). So *H4.6* is strongly supported. Similarly, market turbulence also negatively moderates the effect of technological capability on new product development performance, and the path coefficient is -0.24 ($t = 1.98$). In comparison, we found that technological turbulence and learning orientation positively, but marginally moderates only the relationship between technological capability and overall business performance, the path coefficient is 0.18 ($t = 1.89$) and 0.13 ($t = 1.94$).

5. Discussion and conclusion

Consistent with the conceptual framework, technological capability has not only a direct but also an indirect impact on overall business performance and new product development performance with customer value as the mediator. Furthermore, the effects of technological capability are contingent on several contextual factors. Such results are intriguing because it suggests that the effect of technological capability by itself is probably not as strong as that when customer value and other contingent factors are taken into consideration. It can exert more impacts on business performance by way of creating and delivering superior customer value or interacting with, for instance, environmental turbulence and learning orientation. This implies that given the likely association between technological capability and customer value and its interactions with environmental turbulence and learning orientation, an alternative explanation of earlier findings of a direct positive link between technological capability and business performance results in the potential of technological capability in stimulating and catalyzing such intermediate or contingent variables.

As our empirical models show, the effect of technological capability is contingent on environmental turbulence and learning orientation. The moderating effect of market turbulence is negatively significant. This implies that the more turbulent the market is, the weaker the impact of technological capability on new product development performance and customer value. In comparison, the moderating effects of technological turbulence is very weak, and the effects size is small but positive, which means that the more technologically turbulent the environment is, the stronger the impact of technological capability on overall business performance and this is consistent with Wang *et al.* (2004b). Similarly, the moderating effect of learning orientation is also weak, and the effects size is small but positive. In other words, the more learning-oriented a firm is, the stronger the effect of its technological capability on overall business performance. This is probably because of the nature of technological capability, which requires a firm to keep, for instance, open-minded enough to capture the trend of technology development, accumulate useful knowledge continuously and deploy current technology more effectively. Plausible explanations for these unsupported hypotheses may be that the importance of contingent factors has not been fully recognized and utilized by high-tech firms in China for superior customer value and business performance given the special transitional phase from planning economy towards market economy.

6. Implications

The key theoretical contribution is that while supporting the general thrust of the resource-based theory, we also offer important qualifications to the theory. Contrary to the mediating and moderating logic in the resource-based theory that heterogeneous resources and capabilities are not sufficient in themselves to directly enhance business performance independent of business environments, scholars typically model technological capability as the direct determinant of business performance with little attention given to potential intervening and moderating variables. In this study, we find such a differential power of technological capability that its effect on business performance may be completely or partly mediated, and moderated. Besides the more accepted view that technological capability contributes to business performance, our findings suggest that technological capability transforms its achievable value potential into reality partly through, if not only, customer value creation and delivery based on the logic of better suited to meet customer needs, which has not attracted enough attention in empirical technology and strategy-related research. Although competitive rivalry is recognized in RBV, few studies have modeled empirically technological capability and customer value as an integral part of the explanatory processes for competitive advantage. The mediating role of customer value suggests the need for an explicit integration of customer value in the RBV analytical framework. By calling attention to customer value and customer needs, the framework also facilitates the design of strategies to influence customer perceptions regarding their needs and their choice sets. This is consistent with a large and growing segment of strategy literature that emphasizes a customer-focused approach (Day, 1994). The other aspect that does not get much attention is that the impact of technological capability on business performance may depend on contingent factors. We have examined empirically the contingencies in terms of environment turbulence and learning orientation, and the applicability of the extended RBV within a typical context of a developing economy and a relatively new context of high-tech firms.

Our findings also suggest specific implications for managers. For example, managers educated on the direct effects of organizational capabilities on firm performance tend to believe that a whole host of competitive advantages will fall into places as they invest in these unique resources. This paper appears to temper this conviction by increasing awareness that capabilities do not necessarily lead to superior performance unless they generate superior customer value, which then affords a firm the insights about how to enhance the impact of technological capability by the application of organizational learning theory. Specifically, managers should be cautious in building and strengthening technological capability for sustainable competitive advantages. Not only its direct impact on overall business performance and new product development performance should be stressed, but also its indirect impact mediated by variables such as customer value should be emphasized. Furthermore, as shown in our empirical structural equation models, market turbulence negatively moderates the impact of technological capability on new product development performance and customer value while technological turbulence and learning orientation positively moderate the impact of technological capability on overall business performance. These findings provide more useful suggestions for managers to leverage technological capability for superior performance. Furthermore, they also imply that the practices of technology management for China firms have to take contingent factors such as environmental turbulence and learning orientation into consideration in order to improve the effectiveness and efficiency of technology management investment.

7. Limitations and future research directions

The study has limitations that need to be acknowledged. First, the cross-sectional design prevents us from making strong claims of causality. Thus, collecting longitudinal data and experimental design are expected to infer definitive causal effects. Secondly, our analysis is based on the perceptual data by taking the key informant approach. Such retrospective perceptual data is extensively used in strategy and marketing research (Venkatraman and Ramanujam, 1986), and some scholars argue that choosing the appropriate key informant help improve data accuracy (Huber and Power, 1985). In spite of such evidence, others have advocated the use of multiple informants for cross-validation of data (Phillips, 1981) and it is believed that multiple key informant approach may be more favorable in future research although the result of one-factor test shows that common variance bias is not a significant problem in this study (Podsakoff and Organ, 1986). In addition, our results are based on a sample of high-tech firms in China, which may limit the generalizability of the findings. This implies that this study needs to be replicated across different samples. Besides, technology management is so complex that researchers and managers have to broaden their visions beyond technology capabilities, take more other important factors into consideration and explore their interaction effects.

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