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Full Length Research Paper

Innovation strategy as a mediator among social networks, innovative culture, and technological capability - An empirical Study of the ICT industry in Taiwan

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This paper develops a conceptual framework and discusses the interrelationships among innovative culture, social networks, innovation strategy, and technological capability. Based on resource-based theory, this research employs the internal (innovative culture) and external (social networks) resources to examine their influences on technological capability. The role of innovation strategy is discussed as a mediator, and the Information and Communication Technology (ICT) Industry in Taiwan is examined. The results show that social networks as well as innovation strategy have a positive relationship with technological capability; innovative culture and social networks have a positive relationship with innovation strategy; innovation strategy acts as a mediator of social networks and innovative culture has a positive relationship with technological capability. However, the relationship between innovative culture and technological capability is not significant. All of the findings completely or partially support our research hypotheses. We conclude with a discussion of the managerial implications of our findings and directions for future research.

Key words: Social networks, innovative culture, innovation strategy, technological capability.

INTRODUCTION

With the advent of a knowledge-based economy, technological capabilities are recognized as the driver of firms' performance and economic growth. Technology capabilities are generated and disseminated through transmission channels and interaction mechanisms among various actors, creating technological innovations and eventually exerting a crucial impact on the productivity of socio-economic systems (Lundvall, 1992; OECD, 1992; Nelson, 1991). In particular, the diffusion of information and communications technology (ICT) is now growing at an accelerated rate. ICT not only activates and exchanges knowledge, but also encourages relationships among participating agents. In developing countries like Taiwan, ICT knowledge diffusion is thus very important in spreading knowledge across other industries, subsequently boosting technological capabilities in the ICT and other industries. Archibugi and Coco (2004) argued that technological capabilities have always been a fundamental component of economic growth and welfare, but noted that they are far from being uniformly distributed across countries, regions and firms. The ICT is made up of dedicated information technology firms, which include those that produce computers and peripheral equipment, data storage and data devices, as well as telecommunication firms. Such companies need to create a synergy effectiveness of internal (innovative culture) and external (social networks) resources by adopting a far-sighted innovation strategy to boost both technological capabilities and firms' performance. It is widely recognized in the existing literature widely that technological capabilities are vital for long-term sustainable growth. From the micro-level viewpoint, technological capabilities are defined as the knowledge and skills that a firm needs to acquire, use, adapt, improve, and create new technology (Bell and Pavitt, 1993; Lall, 1993). Some developing countries use the

innovation strategy of technology transfer (Pietrobelli, 2000), while multinational enterprises (MNEs) operate across national boundaries (Cantwell, 1989, 1995) in order to gain technological capabilities and strengthen firms' performance. The development of technological capabilities is essentially the outcome of many complex interactions among individuals, firms, and other organizations within specific networks (Bell, 1984; Malerba, 1992; Lundvall, 1992; Edquist and Johnson, 1997). Consequently, such level of social networks and the profiles of individual firm's innovation strategies are important due to their impact on the acquisition of technological capabilities (Cantwell and Iammarino, 2003; Iammarino, 2005). Interestingly, the notion of a link between innovation strategy and technological capability (Beard and Easingwood, 1996; Easingwood and Koustelos, 2000; Linneman and Stanton, 1992; Hsieh and Tsai, 2007), as well as the social networks and technological capability has been presented in a number of previous studies (Aldrich et al., 1989; Birley, 1985; Donckles and Lambrecht, 1997; Farr-Wharton and Brunetto, 2007; Gulati et al., 2000; Hoang and Antoncic, 2003; Madsen, 2007; Malecki, 1997; Teece, 1986; Hsieh and Tsai, 2007).

In addition, Koc and Ceylan (2007) proposed three determinants of innovative capacity – internal technological environment, idea generation and technology acquisition and exploitation. The literature has also highlighted some reasons that account for the increased importance of innovative culture (Lemon and Sahota, 2004). For example, Tidd et al. (2001) pointed out that the key role of innovation in managing the uncertainty facing organizations and creating added value is becoming recognized as increasingly important, just like the dynamic knowledge capabilities underpinning it. The ability of an organization to 'learn' means that knowledge must be utilized on problems and opportunities as they emerge, and such knowledge is generated through an ongoing evaluation of innovation, from idea generation through to downstreaming, operationalization and comercialization. Innovative culture has been recognized as a primary determinant within innovation, and the need to better understand this relationship or process is a necessary prerequisite to nurturing it in a more structured and systematic manner.

Innovation is holistic in nature, and is inseparable from the culture that facilitates or constrains the ability to 'add value' (Lemon and Sahota, 2004). Furthermore, researchers studying innovation have tended to examine the relationship between innovation and organizational climate (Abbey and Dickson, 1983; Dunegan et al., 1992). Hurley (1995) noted a lack of quantitative research at the group or organization level to systematically examine the effect of organizational culture on technological capabilities, as have a number of other researchers (West and Farr, 1989; Capon et al., 1990; Hoffman and Hegarty, 1993). However, there is a general consensus that to remain competitive, an organization must efficiently and effectively create, capture, harvest, share, and apply its technological capabilities under a synergistic system of internal and external resources and a well-considered innovation strategy.

Hence, working from the resource-based theory, this article provides pragmatic support to previous research by discussing a recent empirical investigation that was conducted by the author. The purpose of the research was three-fold. First, the aim of the study was to describe the specific content of innovative culture, social networks, innovation strategy, and technological capability. Second, the study identified the primary resources needed during the adoption of an innovation strategy for technological capability, specifically, the social networks and innovative culture required. Third, the market characteristics and how they interact with a firm's internal and external resources were explored, with particular emphasis on the relationship between innovation strategy and technological and enterprise competitiveness for ICT firms.

The remainder of this paper is structured as follows. First, this study reviews the literature to uncover details of the related concepts and variables, and then discusses the interrelationships among them in the proposed research model. A number of hypotheses are then presented, followed by a description of the methodology that is adopted to examine them. Next, the statistical results are reported, along with their analysis. Finally, the implications of the findings, limitations of the work, and suggestions for future research are provided in the closing section.

THEORETICAL BACKGROUND

Technological capability

The definition of technological capability varies in the literature, depending on the aims of the researchers. Lall (1990) defined it in a narrow sense as the capability to execute all technical functions entailed in operating, improving, and modernizing a firm's productive facilities. Kim (1997) pointed out that in developing countries technological capability could be used interchangeably with "absorptive capacity" (Cohen and Levinthal, 1990), that is, the ability to absorb existing knowledge, assimilate it, and in turn generate new knowledge. Therefore, technological capability is widely seen as the root of a firm's long-term competitive advantage (Duysters and Hagedoorn, 2000; Henderson and Cockburn, 1994; Kim, 2000; Lee, Lee, and Pennings, 2001; Nelson, 1991), and the driving force of innovation, consisting of the technological knowledge, trade secrets, and know-how engendered by R&D and other technology-specific intellectual properties or patents protected by law (Dollinger, 1985; Lee et al., 2001).

In the high-tech sector, a particular product can utilize technology from several other fields, and possible infringements of other firms' patents cannot be easily predicted at the start of a research and development (R&D) program (Grindley and Teece, 1997). Firms in this industry must either continually make large investments in R&D to nurture their technological capability to bring technologies to the table in cross licensing negotiations, or face a greater amount of royalties charged by patent estates (Grindley and Teece, 1997). Therefore, technological capability is a vital strategic resource for firms, especially high-tech ones, if they are to improve or maintain their market positions. In summary, technological capability can be defined as the capability to make effective use of technical knowledge and skills, not only in an effort to improve and develop products and processes, but also to improve existing technology and to generate new knowledge and skills in response to a competitive business environment.

A number of objective and subjective indicators can be used to measure the elements of technological capability, and the indicators used may vary depending on the capability being assessed. The indicators must be measurable from available data, and must also satisfy the criteria for reliability and validity. For example, Abeysingbe and Paul (2005) defined the construct of technological capability for the case of Sri Lanka Telecom as including creative, design and engineering, marketing and selling, servicing, acquisition, human resources development, information technology, and strategic planning capabilities. In addition, Hsieh and Tsai (2007) wrote that technological capability consists of technological knowledge, trade secrets, and know-how engendered by R&D and other technology-specific intellectual property (Dollinger, 1985; Lee et al., 2001) or patents protected by law. Garcĭa-Muiňa and Navas-López (2007) proposed that the construct of technological capability is composed of exclusive technological exploitation capabilities, non-exclusive technological exploitation capabilities, and technological exploration capabilities. Oyebisi et al. (2004) discussed technological capability in the Nigerian telecommunications industry, and claimed that it included investment, production, major change, linkage and R&D capabilities. Archibugi and Coco (2004) proposed a new indicator of technological capability for developed and developing countries (ArCo), that includes the creation of technology (patents, scientific articles), the technological infrastructures (Internet penetration, telephone penetration, electricity consumption), and the development of human skills (tertiary science and engineering enrollment, mean years of schooling, literacy rate).

Based on a review of the above studies, in this work we use the indicators in Abeysinghe and Paul (2005), namely: creative, design and engineering, marketing and selling, servicing capability, acquisition, human resources development, information technology and strategic planning capabilities.

Social networks

Social networks are social structures made of organizations (or individuals) called “nodes”, which are connected by one or more specific types of interdependency, such as the relationships in a strategic alliance and supply chain, and when conducting knowledge sharing. The existing literature notes that social networks are becoming increasingly important, as they provide firms with access to markets, information, technology, and other resources which can improve the chances of survival and growth (Aldrich et al., 1989; Birley, 1985; Donckles and Lambrecht, 1997; Farr-Wharton and Brunetto, 2007; Gulati et al., 2000; Hoang and Antoncic, 2003; Madsen, 2007; Malecki, 1997; Teece, 1986). Furthermore, networks of collaborative relationships among firms and other institutions are widely recognized as an important organizational form of innovative activity. From a network perspective, the study of strategic alliances or the use of network evolution models has acquired growing popularity with the recognition that social networks are influential in determining cumulative firm outcomes (Ahuja, 2000; Cowan et al., 2002; Jackson and Wolinsky, 1996; Jackson and Watts, 1998; Powell, 1996; Walker et al., 1997). However, the literature provides widely different interpretations of such networks, ranging from economic explanations based on alternative theoretical models, such as the transaction cost theory or the competence-based view of organizations, to social approaches based on cognitive dissonance theory to discuss the related psychosocial issues. Importantly, knowledge diffusion occurs through interaction, and thus the structure over which organizations interact influences the scope of diffusion and thus the innovative potential of firms (Cowan and Jonard, 2004).

Analysis of how social networks shape organizational performance and industrial change is also spreading within firm research (Baker and Faulkner, 1991; Faulkner and Anderson, 1987; Sorenson and Waguespack, 2006; Delmestri et al., 2005, Cattani et al., 2006). Two key observations can be derived from this literature. First, social networks with short average path lengths (that is, the average number of “degrees” between any two agents in the network) are good for the transmission of new practices, as members can easily reach each other and mobilize information, legitimacy or other resources, and thus learn from each other (Baum and Oliver, 1992; Caroll and Hannan, 2000; Cattani et al., 2006).Such a network may substitute for integration, as it holds transaction costs down among its members through reputation effects, social trust and reciprocity. Second, social networks with short path lengths but also a high degree of clustering (density of interconnectedness) may

be prohibitive to the spread of new organizational forms, as their closure and lack of opportunities (or "structural holes" (Burt, 1992)) blocks new entrants (Granovetter, 2005; Uzzi and Spiro, 2005).

Based on the above, we summarize the construct of social networks to include the control capability of resources in social networks, having a good relationship with suppliers and distributors, and the power to control social networks (Baker and Faulkner, 1991; Faulkner and Anderson, 1987; Sorenson and Waguespack, 2006; Delmestri et al., 2005, Cattani et al., 2006).

Innovation strategy

Faced with increasing international competition, innovation has become a central focus in firms' long term strategies. An important aspect of organizations' strategic posture is the extent to which they differentiate themselves from competitors by investing in R&D and emphasizing product or process innovations (Spanos and Lioukas, 2001), labeled hereafter as their "innovation strategy". For example, the extent to which firms emphasize new product development relative to competitors can lead to superior performance (Bettis and Mahajan, 1985). In addition, Poon and MacPherson (2005) defined innovation strategy as being divided into applied research, marketing capability, and new product development, all of which can have positive effects on firms' performance.

However, despite the acknowledged benefits of an innovation strategy for firms' performance, the link between the two is not straightforward (Li and Atuahene-Gima, 2001). As Capon et al. (1990) pointed out, whereas a majority of studies discover a positive relationship between an innovation strategy and firm's performance; in some cases, some research indicates no relationship or even a negative one between them.

Some theories of innovation focus on the benefits with regard to a firm's competitive advantage. For example, one important insight arising from Schumpeter's ideas (1975) is that innovation can be seen as "creative destruction" that restructures the whole market in favor of those firms that grasp discontinuities faster. Schumpeter wrote that "the problem that is usually visualized is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them". Second, in an article covering the Afuah (1998) wrote that the technological knowledge behind innovation can be divided into two dimensions: knowledge of the components and knowledge of the linkage between them, called architectural knowledge. The result is a two-by-two matrix with four possible types of innovation: incremental, modular, radical and architectural. Third, Teece (1997) clarified that two factors - imitability and complementary assets - will have a strong influence in determining who will ultimately profit from an innovation. Imitability refers to how easily competitors can copy or duplicate the technology or process underpinning the innovation. Complementary assets include any activity that gravitates around the core innovation, such as distribution channels, reputation, marketing capabilities, strategic alliances, customer relationships, and licensing agreements, among many others.

Based on the above studies, we define innovation strategy as being divided into applied research, marketing capability, and new product development (Poon and MacPherson, 2005).

Innovative culture

Growing attention is being paid to innovation as a key success factor in a firm's sustainable competitive advantage. A 2006 IBM survey of nearly 800 CEOs in 20 countries probed leadership attitudes and strategies with regard to enhancing innovation. Among the top barriers to innovation that CEOs cited was an unsupportive culture and climate (Vona and DeMarco, 2008). Although one might argue that CEOs are ultimately responsible for creating and sustaining such a culture, even when leaders believe in the power of new ideas and risk-taking, they may find themselves unable to motivate and support people to take risks and promote new ideas. Therefore, how to raise the innovative culture into the general managerial environment seems to be the most important factor with regard to increasing the innovativeness of a firm. Hult et al. (2004) also proposed that innovativeness refers to "a firm's capacity to engage in innovation: that is, introduction of new processes, products, or ideas in the organization". This means a firm needs an innovative culture to foster innovativeness or innovative capacity, and this is among the most important factors influencing performance (Hurley and Hult, 1998; Porter, 1990). There have some ways that firms can create and sustain a culture of innovation within their organizations (Vona and DeMarco, 2008), and these include: offering incentives and rewards (Amabile, 1997; Tidd, Bessant, and Pavitt, 1997), shaping the right perceptions about risk-taking (Ansoff, 1979; Tushman and O'Reilly, 1996), infusing diversity into the organization (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995; Fleming and Koppelman, 1997), capitalizing on internal networks (Deshpande´ and Webster, 1989; Deshpande et al., 1993) and improving external collaboration (Hurley and Hult, 1998).

Based on a review of the literature outlined above, we define an innovative culture as one that encourages people to innovate, communicate and accept new ideas, as well as empowers them to make decisions (Deshpande et al., 1993).

Conceptual framework

Figure 1 demonstrates the conceptual framework

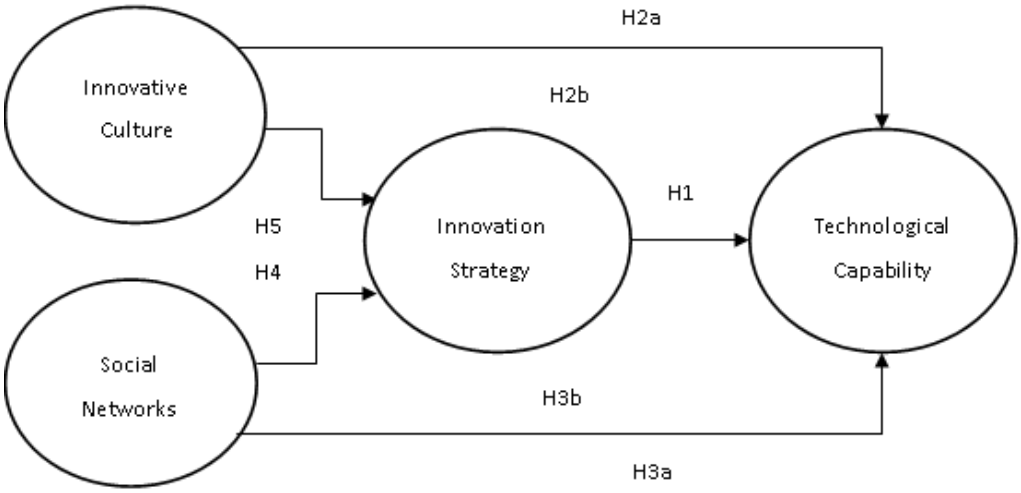


Figure 1. Conceptual framework.

investigated in this study. The framework indicates that the adoption of technological capability is affected by two resource factors of a firm: innovative culture and social networks. The conceptual framework further proposes that these relationships are mediated by the degree of innovation strategy. Specific hypotheses relating to the interrelationship among the variables, and their underpinning logic, are described in the following section.

Theoretical development and hypotheses

Innovation strategy and technological capability

Porter (1985) suggested that the technology employed or developed by the firm significantly determines any cost leadership, differentiation position, or innovation strategy, and, in particular, the firm's ability to lead and sustain technological change in its industry ultimately confers a sustainable competitive advantage. Since technological capabilities determine the firm's ability to perform R&D, these should positively enhance the firm's competitive advantage. For example, a firm engaged in a innovation strategy can further enhance the positive relationship between this strategy and performance if it also has considerable technological capabilities, that is, technological capabilities will likely enable the firm to pioneer more efficient manufacturing processes and lower the material content of its product, simplifying its logistics, and/or enhancing economies of scale (Porter, 1985). Similarly, superior technological capabilities also enhance the differentiator's competitive advantage by improving product quality, adding features and value, or enhancing economies of scope (Porter, 1985).

Adler and Shenbar (1990) identified four types of technological capabilities, as follows: (1) the capability of satisfying market requirements by developing new products; (2) the capability of manufacturing these products by using appropriate process technology; (3) the capability of satisfying future needs by developing and introducing new products and new process technology and (4) the capability of responding to unanticipated technological activity brought about by competitors and unforeseen circumstances. These capabilities exist at both the individual and firm levels. Furthermore, Ortega (2010) discussed the role of technological capabilities in moderating the relationship between competitive strategies and firms' performance in the Spanish ICT industry. Her results suggested that the theoretical prescriptions of RBV and strategy (including market orientation, process improvement orientation, human group orientation, cost leadership orientation, quality orientation and specialization orientation) must be strategically combined within the firm maximization effect (including managerial capabilities, market capabilities, and technological capabilities). We can thus propose the following hypothesis:

Hypothesis 1. Innovation strategy positively influences technological capability.

Innovative culture and technological capability

Two of the earliest and most important works on the topic of innovation concerned the connection between innovation and culture (Hurley, 1995). Barnett (1953) suggested that cultural context affected the technological capabilities of firm, while Burns and Stalker (1961) also pointed out that organizational culture has an effect on innovative capacity.

The theoretical argument concerning culture is that

through a combination of history, environment, reward systems, and leadership, a set of norms and values are established regarding how things should work and how people should behave in a firm (Schein, 1985). Technological capabilities are a specific aspect of firm's performance that is hypothesized to be influenced by innovative culture. Where the firm develops norms and values that emphasize innovation and receptivity to new ideas, processes and behaviors will follow that increase technological capabilities; that is, a culture that values innovation tends to produce innovative outcome (Quinn, 1988). Based on this, we present the second hypothesis:

Hypothesis 2a. Innovative culture positively influences technological capability.

Furthermore, an important aspect of organizations' strategic approach is the extent to which they differentiate themselves from competitors by investing in R&D and emphasizing product or process innovations (Spanos and Lioukas, 2001), labeled hereafter as a firm's "innovation strategy". Therefore, a cost leadership or differentiation strategy (Porter, 1990) can stimulate the relationship between innovative culture and technological capability. Bettis and Mahajan (1985) also proposed that if firms emphasize new product development more than their competitors then this can lead to superior performance because of the associated ability to differentiate between the firms involved.

Burgelman et al. (2004) suggested that technological capabilities are a comprehensive set of organizational characteristics that are facilitated and supported by its technological innovation strategies. Evangelista et al. (1997) stated that innovative activities are a central component of the technologically innovative culture of firms, and the most important intangible innovation expenditure. Dierickx and Cool (1989) argued that successful technological innovation depends not only on technological capability, but also on other critical capabilities in the areas of manufacturing, marketing, culture, organization, strategy planning, learning, and resources allocation. Therefore, we propose the following hypothesis:

Hypothesis 2b. Innovation strategy mediates the relationship between innovative culture and technological capability.

Social networks and technological capability

Based on a review of the prior studies, it can be seen that social networks are becoming increasingly important, as they provide firms with access to markets, information, technology, and other resources that can improve a firm's chances of survival and growth (Aldrich et al., 1989; Birley, 1985; Donckles and Lambrecht, 1997; Farr-Wharton and Brunetto, 2007; Gulati et al., 2000; Hoang and Antoncic, 2003; Madsen, 2007; Malecki, 1997; Teece, 1986). In addition, there is now an increasing consensus in the academic literature that a firm's embeddedness in a network of interfirm relations is important for its economic and technological innovation (Nooteboom, 1992; Hagedoorn, 1993; Powell et al., 1996; Rowley et al., 2000; Ahuja, 2000; Owen-Smith and Powell, 2004). The empirical evidence has also indicated that this relationship between network embeddedness and technological capability can be found in industries as diverse as chemicals (Ahuja, 2000), biotechnology (Baum et al., 2000; Powell et al., 1996), semiconductors (Stuart, 1998), textiles (Uzzi, 1997), personal computers (Hagedoorn and Duysters, 2002) and banking (Zaheer and Bell, 2005). More recently, some studies have started to unravel this notion of embeddedness in order to understand in what specific ways it contributes to a firm's technological capability. Based on this, we present the following hypothesis:

Hypothesis 3a. Social networks are positively related to technological capability.

A network, as a concept or as a diagram, is often used to represent the multiple relations that lead to the development of technological capabilities within a firm. These relations may suggest the idea of a 'collective activity' (Alter, 2000) or of a socio-technical construction (Callon, 1989; Latour, 1988) that combines technological capabilities and resources according to the innovation strategies implemented by an inventor. Therefore, we can propose the following hypothesis:

Hypothesis 3b. Innovation strategy mediates the relationship between social networks and technological capability.

Social networks and innovation strategy

As noted in the previous section, social networks are now viewed as increasingly important in related literature, and the forces of globalization imply a more international scope of competition, along with global dispersion of innovative activities caused by the restructuring of the value chain in most internationalized firms. Companies have evolved over recent decades toward the development of new production process, and inter-organization partnerships have become a core component of innovation strategy (Powell and Grodal, 2005). Therefore, the internal and external relationships of social networks are both important for innovation strategy. We can propose the following hypothesis:

Hypothesis 4. Social networks positively relate to innovation strategy.

Innovative culture and innovation strategy

From a dynamic point of view, strategic flexibility is

necessary for a firm's growth (Hamel and Heene, 1994), and long-term growth is supported by a continuous process of acquiring new resources and capacities that generate competitive advantages. A suitable innovation strategy thus enables the firm to modify its resource base and capacities to respond to dynamic changes in the environment

In addition, growing attention is being paid in the literature to innovation as a key success factor in a firm's sustainable competitive advantage, and much has been written about the process of innovation from idea generation through downstreaming and operationalization to commercialization. Moreover, a truly innovative firm must be embedded with a strong culture that stimulates the engagement in innovation behavior (Skerlavaj et al., 2010). What is often neglected in practice is the importance of culture in the literature, as it is that not just knowledge that needs to be acquired and processed, but the right set of attitudes and values are also necessary for innovations to occur (Terziovski, 2008). Therefore, an innovative culture has been recognized as a primary determinant of innovation, and a better understanding of this relationship or process is a necessary prerequisite to nurturing innovation in a more structured and systematic manner (Lemon and Sahota, 2004). Furthermore, innovative culture facilitates the communication and collaboration between groups which is needed for implementation (Shepard, 1967; Angle, 1989; Damanpour, 1991; Daft and Becker, 1978), nurtures and encourages innovative ideas (Waldman and Bass, 1991), and increases involvement and the commitment to innovate (Damanpour, 1991; Thompson, 1965). Therefore, we propose the following hypothesis:

Hypothesis 5. Innovative culture positively relates to innovation strategy.

METHODS

Samples

To carry out the empirical study, this research has chosen to focus on the Information and Communication Technology industry in Taiwan. The 500 firms examined are a random sampling from the 1,000 ICT companies included in the Largest Corporations in Taiwan - TOP 5000 report (2009), produced by the China Credit Information Service (CCIS) Corporation.

After sending the questionnaire to the R&D departments of these firms twice, separated by a three-week interval, this study received 197 valid responses, giving an acceptable response rate of 39.4%, with details of the respondent firms given in Table 1. Furthermore, we developed a t-test for all the variables included in the study to examine the differences between the firms that responded during the first three weeks (112) and the firms that responded later (85). The results do not show any significant differences between these two groups. Moreover, this study compared the mean value of the size variable for all the firms and those included in the sample and obtained similar values in both cases. Therefore, following Armstrong and Overton (1977), a non-responsive bias was not found.

Questionnaire

The questionnaire design was developed from a wide review of the literature using a five-point scale for each item, which allowed our study to measure the great majority of analyzed variables from valid scales. In order to improve the content validity, a two-stage analysis was designed to evaluate the reliability of the questionnaire. The first stage developed a pre-test with thirty firms in order to examine the reliability and validity of the questionnaire, and then in the second stage the revised questionnaire was mailed to all the firms to gather opinions from the heads of their R&D departments. These two stages are detailed below.

Pre-test analysis

In this stage, the questionnaire items were tested with regard to the reliability and validity of each construct before the formal questionnaire was sent out to the firms. Based on the results of the pre-test, this study deleted some items for each construct in order to increase the reliability. The revised definitions of the dimensions are given in Table 2.

Common method bias

A Harman one-factor test was used to assess the potential for common method bias in the data (Podsakoff and Organ, 1986). The results of a factor analysis of the dependent and independent variables accounted for 75.389% of the total variance, with the first factor accounting for only 23.82% of the variance. Therefore, common method bias is unlikely to be a concern.

SEM measurement

The SEM model analysis, which was conducted using LISREL 8.72 software, was divided into two parts. A measurement model was created in order to assess convergent and discriminant validity. Convergent validity was judged by the R^2-values measuring the strength of the linear relationships, the t-values, a significance test of each relationship in the model; and the factor loading for each indicator (Jöreskog and Sörbom, 1993, 1996) and a series of two-factor models, as recommended by Bagozzi et al. (1991) were estimated for the discriminant validity.

The second step in the analytical process was to form the structural model by specifying the causal relations in accordance with the hypotheses. The model tests single causal relations with t-values and factor loadings between the constructs in the model. The entire model will be assessed by chi-squares (normal theory weighted least squares) and degrees of freedom, Comparative Fit Index (CFI), Goodness-of-fit Index (GFI), Root Mean Square Residual (RMR), Root Mean Square Error of Approximation (RMSEA) (Hu and Bentler, 1995). Furthermore, Hair et al. (1998) suggested that the indicators of adjusted goodness-of-fit Index (AGFI) and Normed Fit Index (NFI) will be examined the fit of structural model too.

RESULTS

Reliability and validity

We evaluated the reliability and validity of our constructs using confirmatory factor analysis (CFA) (Anderson and Gerbing, 1988; Fornell and Larcker, 1981). By using

Table 1. Sample distributions by variables.

Variables	Classification	No. of firms	Percentage (%)	Accumulated percentage (%)
Employees	Under 500 employees	116	58.9	58.9
	500～1000 employees	26	13.2	72.1
	1000～1500 employees	12	6.1	78.2
	1500～2000 employees	15	7.6	85.8
	2000～2500 employees	4	2.0	87.8
	2500～3000 employees	9	4.6	92.4
	3000～3500 employees	5	2.5	94.9
	Over 3500 employees	10	5.1	100.0
R&D per Incomes	less than 0.9%	101	51.3	51.3
	1.0～1.9%	37	18.8	70.1
	2.0～2.9%	21	10.7	80.7
	3.0～3.9%	6	3.0	83.8
	4.0～4.9%	15	7.6	91.4
	more than 5.0%	17	8.6	100.0
Types of industry	Computer peripheral industry	105	53.3	53.3
	IC industry	61	31.0	84.3
	Communication industry	31	15.7	100.0

Table 2. The exploratory factor analysis (EFA) for each construct.

Construct	Item-total correlations	Cronbach's α	Dimensions after factor analysis	Cumulative variances
Innovation strategy	All > 0.5	0.946	Applied research (I1) Marketing capability (I2) New product development (I3)	83.45%
Social networks	All > 0.5	0.949	The necessary and scarcity resources of network (S1) Has a controlling right in its networks Has a good relationship with distributors and suppliers	88.15%
Technological capability	All > 0.5	0.958	Innovation capability Design and engineering capability Supply chain management capability Sales & marketing capability	85.35%
Innovative culture	All > 0.5	0.852	Encourages staff to generate new ideas Accepts new ideas Staff are authorized to make decision Encourages staff to communicate with each other	84.55%

Table 3. The results of CFA for each construct.

Construct	χ^2	χ^2/df	CFI	NFI	GFI	RMSEA
Innovation strategy	160.41	1.87	0.99	0.97	0.88	0.046
Social networks	103.35	3.975	0.95	0.94	0.87	0.05
Technological capability	182.26	2.398	0.98	0.96	0.86	0.048
Innovative culture	55.42	2.31	0.98	0.97	0.93	0.045
Suggested value	Small is better	< 3 or < 5	>0.9	>0.9	>0.9	<0.05
Research support	Jöreskog and Sörbom, 1996	< 3 Carmines and Mclver, 1981 < 5 Wheaton, 1987	Bentler, 1990	Bentler and Bonnett, 1980	Jöreskog and Sörbom, 1996	Browne and Cudeck, 1993

LISREL 8.72, we investigated all four constructs (involving 47 question items) and separated four CFA models using all the surveys (N = 197). The resulting measurement model was found to fit the data reasonably well, as did the values of CR and AVE (Hair et al., 1998; Anderson and Gerbing, 1988), providing support for convergent validity (Table 3).

To assess the discriminate validity, a series of two-factor models were estimated, in which individual factor correlations were restricted, one at a time, to unity by using LISREL 8.72. The fit of the restricted models was compared with that of the original one. In total, we examined four models - 18 pairs of comparisons - using LISREL 8.72. The chi-square changes ($\triangle\chi^2$) in each model (Table 4), constrained and unconstrained, were significant, $\triangle\chi^2 > 0$, suggesting that constructs had discriminant validity.

Table 5 reports the reliabilities of the multiple-item model, along with construct correlations and descriptive statistics for the scales. Tables A-1~A-4 (Appendix) also demonstrate that all the reliability estimates (including composite reliability (CR), average variance extracted (AVE) for each construct, and LISREL 8.72 based composite reliabilities) are well beyond or close to the threshold levels suggested by Nunnally (1978) and Fornell and Larcker (1981). As a check for discriminant validity, the variance extracted for each construct was greater than the squared latent factor correlations between pairs of constructs in Table 5. After conducting these tests, we conclude that our measures have adequate discriminant and convergent validity.

Conceptual model analysis

A structural equation model (SEM) is used to test hypotheses 1 to 5. LISREL 8.72 was adopted to analyze SEM, which verifies how and why the variables influence each other. Figure 2 shows the results of the SEM analysis. The χ^2 statistic for the model is significant (χ^2=220.73, *d.f.*=71, CMIN/df=3.11, NFI=0.95, CFI=0.97, GFI=0.86, AGFI=0.8, RMSEA=0.104, *P*<0.001) and some of the relevant fit indices show a good overall fit, while modified indicators (MI) of model suggest that the structure of the model needs to be modified in order to fit the conditions.

Modified model

This research model was modified based on the recommendations arising from the modification indices and then reexamined. The χ^2 statistic for the model is significant (χ^2=112.24, *d.f.* =64, CMIN/df=1.754, NFI=0.98, CFI=0.99, GFI=0.92, AGFI=0.88, RMSEA=0.062, *P*=<0.001) and the other relevant fit indices show a good overall fit (Figure 3). The analytical results indicate that some of the measurement errors correlated with each other. Therefore, the revision of the modified model is more suitable than the original one when we set up the correlation for them in the revised model.

DISCUSSION AND IMPLICATIONS

After the revisions to the modified model, the direct and indirect effects of each pair of constructs are listed in Table 6, and these can be used to examine the hypotheses, as follows (Table 7).

The results of the path analysis model shown in Table 7 support Hypothesis 1, since the path coefficient and t-value between innovation strategy and technological capability is significantly positive (0.62, 9.23). This result was also found in a study of the ICT industry in Spain (Ortega, 2010). Furthermore, a firm that adopts an innovation strategy can further enhance the positive relation-ship between this strategy and performance if it also has considerable technological capabilities (Porter, 1985). Therefore, we can confirm that continuously undertaking innovation activities is the most important strategy to promote technological capabilities in the ICT industry. In contrast, the path coefficient between innovative culture and technological capability is non-significantly positive (-0.03, -0.45). However, the innovation strategy has a mediating role, and thus a significant positive effect on this relationship (0.27, 4.56).

Table 4. The discriminant validity analysis of each construct.

Model	χ^2	DF	$\Delta\chi^2$
Unconstrained	394.84	32	
Set the covariance between applied research and marketing capability to 1	405.51	33	10.67***
Set the covariance between applied research and new product development	405.77	33	10.93***
Set the covariance between marketing capability and new product development	404.82	33	9.98***
Unconstrained	55.42	24	
Set the covariance between network scarce and necessary resources and has a controlling voice networks	67.76	25	12.34***
Set the covariance between network scarce and necessary resources and with distributors and suppliers of a good relationship	68.96	25	13.54***
Set the covariance between has a controlling right in its networks and a good relationship with distributors and suppliers	66.89	25	11.47***
Unconstrained	628.13	98	
Set the covariance between innovation capability and design and engineering capability to 1	634.91	99	6.78***
Set the covariance between innovation capability and supply chain management capability to 1	628.40	99	0.27***
Set the covariance between innovation capability and sales and marketing capability to 1	636.52	99	8.39***
Set the covariance between design and engineering capability and supply chain management capability to 1	628.52	99	0.39***
Set the covariance between design and engineering capability and sales & marketing capability to 1	630.11	99	1.98***
Set the covariance between supply chain management capability and sales and marketing capability to 1	629.13	99	1.00***
Unconstrained	156.61	29	
Set the covariance between encourages staff to innovate and accept new idea to 1	180.48	30	23.87***
Set the variance between encourages staff to innovate and authorizes staff to make decisions to 1	172.89	30	16.28***
Set the variance between encourages staff to innovate and encourages staff to communicate to 1	185.47	30	28.86***
Set the covariance between accept new ideas and authorizes staff to make decisions to 1	183.50	30	26.89***
Set the covariance between accept new ideas and encourages staff to communicate to 1	187.63	30	31.02***
Set the covariance between authorizes staff to make decisions and encourages staff to communicate to 1	168.38	30	11.77***

$\Delta\chi^2$ is calculated by the base of unconstrained; *** Means P < 0.001.

Table 5. The Pearson correlations of each dimension.

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. The necessary and scarcity resources of networks	3.14	0.91	1													
2. Has a controlling right in its networks	3.29	0.86	0.82**	1												
3. Has a good relationship with its distributors and suppliers	3.03	1.02	0.80**	0.818**	1											
4. Encourages staff to generate new ideas	3.30	0.82	0.461**	0.481**	0.415**	1										
5. Accept new ideas	3.56	0.70	0.318**	0.423**	0.355**	0.590**	1									
6. Staff are authorized to make decisions	2.99	0.72	0.261**	0.273**	0.140**	0.586**	0.523**	1								
7. Encourages staff to communicate with each other	2.98	0.70	0.282**	0.326**	0.290**	0.572**	0.646**	0.671**	1							
8. Applied research	2.82	1.30	0.440**	0.504**	0.432**	0.518**	0.419**	0.310**	0.357**	1						
9. Marketing capability	3.12	0.87	0.317**	0.363**	0.297**	0.423**	0.379**	0.314**	0.270**	0.783**	1					
10. New product development	2.98	1.02	0.362**	0.431**	0.388**	0.449**	0.465**	0.336**	0.401**	0.888**	0.778**	1				
11. Innovation capability	3.07	0.90	0.485**	0.570**	0.461**	0.414**	0.385**	0.343**	0.299*	0.656**	0.618**	0.697**	1			
12. Design and engineering capability	3.29	0.82	0.397**	0.492**	0.353**	0.378**	0.321**	0.322**	0.231**	0.610**	0.614**	0.586**	0.809**	1		
13. Service marketing capability	2.95	1.02	0.447**	0.532**	0.385**	0.387**	0.389**	0.358**	0.316**	0.646**	0.588**	0.673**	0.897**	0.828**	1	
14. Sales and marketing capability	3.20	0.98	0.360*	0.468**	0.361**	0.358**	0.341**	0.301**	0.295**	0.548**	0.545**	0.575**	0.761**	0.833**	0.778**	1

* Means significant at the < 0.01 level with two tails.

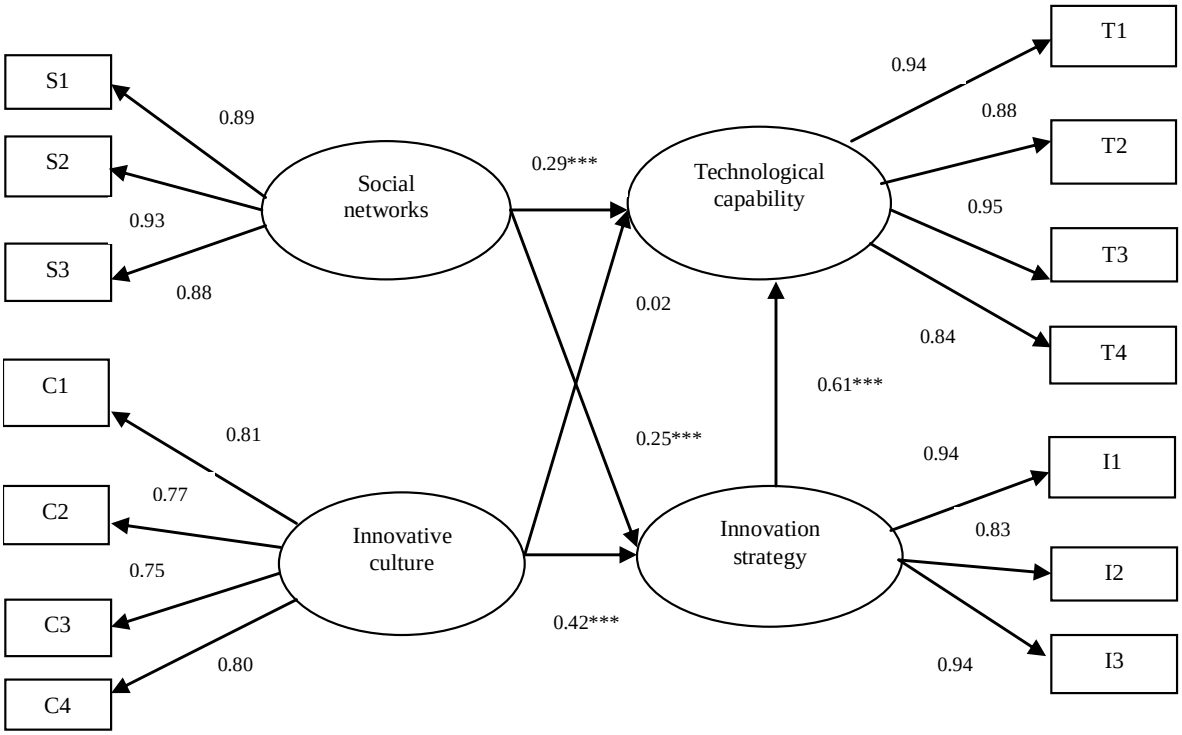
Burns and Stalker (1961) found that a firm's cultural context affects its technological capabilities, while Barnett (1953) pointed out that organizational culture had an effect on innovative capacity. Therefore, a firm should develop norms and values that emphasize innovation and receptivity to new ideas, as this will lead to processes and behaviors that increase technological capabilities, thus developing a culture that values innovation, as this tends to produce innovative outcomes (Quinn, 1988).

There is now an increasing consensus in the academic literature that a firm's embeddedness in a network of interfirm relations is significant for its economic and technological innovation (Nooteboom, 1992; Hagedoorn, 1993; Powell et al., 1996; Rowley et al., 2000; Ahuja, 2000; Owen-Smith and Powell, 2004). Furthermore, several empirical studies have indicated that this relationship between networks and technological capability can be found in industries as diverse as chemicals (Ahuja, 2000), biotechnology (Baum et al., 2000; Powell et al., 1996), semiconductors (Stuart, 1998), textiles (Uzzi, 1997), personal computers (Hagedoorn and Duysters, 2002) and banking (Zaheer and Bell, 2005). In addition, these relations suggest the idea of a 'collective activity' (Alter, 2000) or a socio-technical construction (Callon, 1989; Latour, 1988) that combines technological capabilities and resources according to the innovation strategies implemented by a firm. Therefore, the path coefficient and t-value between social networks and technological capability show significantly positive effect (0.29, 4.68). Moreover, when innovation strategy acts as a mediating role it has a significant positive effect on this relationship (0.16, 3.31). We thus believe that social networks play an important role with regard to increased technological capability, and that this is true for both direct and indirect relationships within the ICT industry.

Finally, the path coefficient and t-value between innovative culture and innovation strategy have a significantly positive effect (0.43, 5.26), as do those between social networks and innovation strategy (0.26, 3.49). Based on the influence of innovation strategy, innovative culture has a greater influence than social networks. Therefore, organizational culture for firms in the ICT industry should pay more attention to raising the level of innovativeness.

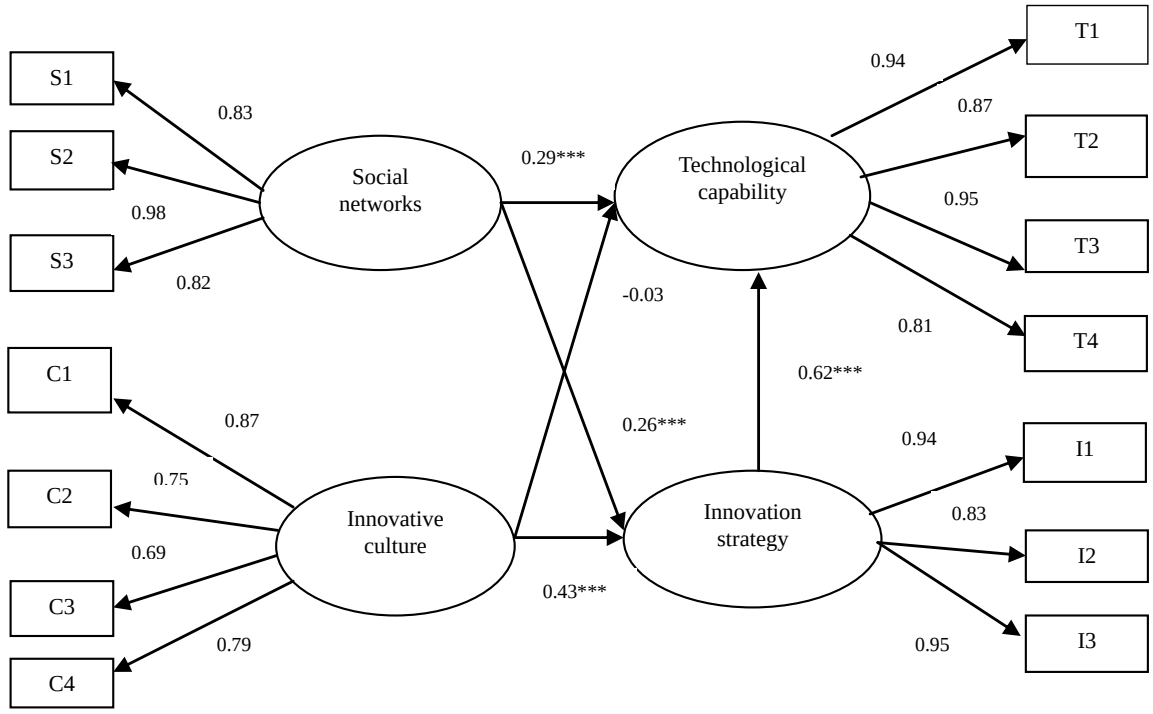
Conclusion

As discussed above, our research clearly indicates that innovation strategy plays different roles and has different influence between exogenous (innovative culture and social networks) and endogenous variables (technological capability). For example, innovation strategy has as a mediating role for the relationship between social



$\chi^2 = 220.73$, *d.f.* = 71, RMSEA = 0.104, $P < 0.001$

Figure 2. Path analysis of the research model.



$\chi^2 = 112.24$, *d.f.* = 64, RMSEA = 0.062, $P < 0.001$

Figure 3. Path analysis of the modified model

Table 6. The path analysis model for latent variables.

The path analysis model for latent variables		Dependent variable			
		Innovation strategy		Technological capability	
Independent variable		The effect of influence	t value	The effect of influence	t value
Exogenous variables	Social networks				
	Direct effect	0.26	3.49***	0.29	4.68***
	Indirect effect			0.16	3.31***
	Total effect	0.26	3.49***	0.45	6.00***
	Innovative culture				
	Direct effect	0.43	5.26***	-0.03	-0.45
	Indirect effect			0.27	4.56***
	Total effect	0.43	5.26***	0.24	3.07***
Endogenous Variable	Innovation strategy				
	Direct effect			0.62	9.23***
	Indirect effect				
	Total effect			0.62	9.23***

* Means P<0.05;** Means P<0.01;*** Means P<0.001.

Table 7. Path model.

Hypothesis	Path	Path coefficient	Result
Hypothesis 1	Innovation strategy ------- Technological capability	0.62***	Supported
Hypothesis 2a	Innovative culture -------- Technological capability	-0.03	Not supported
Hypothesis 2b	Innovative culture -------- Technological capability (Innovation strategy as a mediator)	0.27***	Supported
Hypothesis 3a	Social networks ---------- Technological capability	0.29***	Supported
Hypothesis 3b	Social networks ---------- Technological capability (Innovation strategy as a mediator)	0.16***	Supported
Hypothesis 4	Social networks ---------- Innovation strategy	0.26***	Supported
Hypothesis 5	Innovative culture ------- Innovation strategy	0.43***	Supported

*** Means P < 0.001.

networks and technological capability, as well as the relationship between innovative culture and technological capability. However, the results do not indicate a significant relationship between innovative culture and technological capability. In contrast, the results show that social networks are positively related to technological capability. Furthermore, innovative culture and social networks are positively related to innovation strategy.

Finally, innovation strategy is positively related to technological capability, as was also found by past researchers (Porter, 1985; Adler and Shenbar, 1990; Ortega, 2010). For managers, what has to be noticed is that a specific technological capability which does not relate to innovative culture does relate to social networks.

In this study, social networks are regarded as the linkages between upstream or downstream firms that can directly or indirectly enhance a firm's technological capability, Furthermore, the relationship between innovative culture and technological capability is not significant. Therefore, if firms just focus on raising an innovative culture in the ICT industry, then this will not directly lead to better technological capability. However, the relationship between innovative culture and technological capability is significant when such firms try to use innovation strategy as a mediating tool. Nevertheless, it is still important for firms to invest in creating and sustaining an innovative culture when they attempt to use strategic innovation strategy to enhance technological capability.

Overall, this study contributes to a better understanding of the relationships among innovative culture, social networks, innovation strategy, and technological capability. Moreover, the findings show that innovation strategy

plays an important mediating role among social networks, innovative culture and technological capability. Therefore, R&D managers should plan a suitable innovation strategy when their company employs external (social networks) and internal (innovative culture) resources to enhance their technological capability.

Some of the limitations of this study, which may provide directions for future research, are as follows. One is that future studies should consider more flexible degrees of exploring this issue, such as examining a firm's dynamic capabilities (Teece et al., 1997; Hsieh and Tsai, 2006; Pavlou, 2004; Pettus et al., 2007; Teece, 2007; Wang and Ahmed, 2007). For these kinds of exploration a firm needs partners with presumably (much) larger technological capabilities than those considered here, and we anticipate that this will have major implications for the role of both strategic alliances and vertical integration, as well as for strengthening the related business models.

A second limitation relates to our independent variables. We have counted the external and internal resources of firms as social networks and innovative culture using the resource-based theory. However, the various resources of firms differ in their value, and taking this into account would definitely enrich future work in this field; weighting each resource based on the opinions of R&D managers seems a straightforward way to do this. Such an approach would also enable further study of the validity of our results. A final limitation is that we did not consider the effect of long- and short-term innovation strategies. Different levels of innovation strategy can be weighted according to the 'strength' of their contribution. This would require additional research regarding which innovation strategy type is more instrumental for social networks, innovative culture and technological capability.

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Appendix

Table A-1. The CFA of innovation strategy.

indicators	MLE estimate parameter		composite reliability (CR)	average variance extracted (AVE)
	indicator loadings (λ)	indicator error variances (δ)		
First level - Innovation strategy				
I1. Applied research			*0.97*	*0.91*
I11 Your company is committed to R&D and product development.	0.93**	0.13		
I12 Your company is committed to R&D and has developed a number of intellectual properties.	0.97**	0.07		
I13 Your company is committed to technology, products, and improvement of the work process.	0.96**	0.08		
I2. Marketing capability			*0.89*	*0.68*
I21Your company has a higher ratio of R&D to income than other companies.	0.78**	0.40		
I22 Your company's marketing strategy is based on different products or a market mix that can effectively develop a suitable market segmentation policy.	0.84**	0.29		
I23 Your company can specifically focus on the target market for each product.	0.83**	0.31		
I24 Your company's marketing strategy is based on the target market, the importance of the products and the unique benefits that it has.	0.85**	0.29		
I3 New product development			*0.88*	*0.70*
I31 Your company can change at any time in response to the dynamic external environment, and adopt an appropriate product development strategy.	0.94**	0.12		
I32 Your company often introduces new technology to improve products or processes.	0.69**	0.53		
I33 Your company can use suitable method to develop product a quality assurance system.	0.87**	0.24		
Second level - Innovative strategy			0.94	0.85
I1. Applied research	0.99**	0.02		
I2. Marketing capability	0.79**	0.37		
I3 New product development	0.96**	0.07		
CFI=0.90, GFI=0.71, χ^2=395.55, df=32				

Table A-2. The CFA of social networks.

indicators	MLE estimate parameter		composite reliability (CR)	a average variance extracted (AVE)
	indicator loadings (λ)	indicator error variances (δ)		
First level - Social networks				
S1. The necessary and scarcity resources of network			0.93	0.81
S11 Your company has the ability to get the necessary resources of the network to sustain business survival.	0.92**	0.14		
S12 You company has better capability to hold the necessary resources of network to ensure business growth.	0.91**	0.17		
S13 Your company, relative to other members of the network system, has the ability to set or modify the mode of cooperation with other members.	0.86**	0.26		
S2. Has controlling right in its networks			0.90	0.70
S21 Your company, relative to other members of the network system, has the ability to set their trading type.	0.89**	0.21		
S22 Your company, relative to other members of the network system, has the ability to set the requirements of product quality or technology.	0.90**	0.19		
S23 Your company can derive the assistance and cooperation from upstream and downstream in the network.	0.75**	0.44		
S24 Your company establishes a real-time feedback system upstream and downstream within the network in order to adapt to changing market conditions.	0.80**	0.35		
S3. Has a good relationship with distributors and suppliers			0.89	0.80
S31 Your company can set up a partnership with the members of the network system in any time.	0.81**	0.35		
S32 Your company can adjust the strength of their relationship with the member of the network system in any time.	0.97**	0.05		
Second level – social networks			0.96	0.87
The necessary and scarcity resources of network	0.94**	0.11		
Has controlling right in its networks	0.94**	0.11		
Has a good relationship with distributors and suppliers	0.94**	0.12		
CFI=0.93, GFI=0.78, χ^2=269.32, df=31				

Table A-3. The CFA of technological capability.

Indicators	MLE estimate parameter		composite reliability (CR)	average variance extracted (AVE)
	indicator loadings (λ)	indicator error variances (δ)		
First level - Technological capability				
T1.Innovation capability			*0.92*	*0.71*
T1 Your company has the capability to modify existing processes, applications and service quality.	0.86**	0.26		
T2 Your company has the ability to create new organizational structures.	0.81**	0.34		
T3 Your company has the ability to plan, research and develop a project.	0.92**	0.15		
T4 Your company has the ability to design engineering.	0.77**	0.41		
T5 Your company has the ability to customize products.	0.84**	0.30		
Design and engineering capability			*0.93*	*0.70*
T6 Your company has the ability to build a customer response system.	0.74**	0.45		
T7 Your company has the ability to manage project engineering.	0.90**	0.19		
T8 Your company has the ability to exploit new customers and obtain bargaining power.	0.78**	0.40		
T9 Your company has the ability to develop and maintain service channels.	0.90**	0.18		
T10 Your company has the ability to provide customer services in accordance with contracts.	0.84**	0.30		
T11 Your company has the ability to plan and coordinate marketing activities.	0.84**	0.30		
T3. Supply chain management capability			*0.87*	*0.77*
T15 Your company has the ability to interact with upstream and downstream partners.	0.89**	0.21		
T16 Your company has the ability to manage the cooperative relationship with upstream and downstream partners.	0.87**	0.24		
D. Sale and marketing capability			*0.91*	*0.78*
T12 Your company has the ability to immediately respond to customer service needs.	0.92**	0.16		
T13 Your company has the ability to conduct market research.	0.86**	0.27		
T14 Your company has the ability to provide good customer service.	0.87**	0.24		
Second level – Technological capability			0.97	0.89
Innovation capability	0.96**	0.08		
Design and engineering capability	0.91**	0.16		
Supply chain management capability	0.89**	0.20		
Sales and marketing capability	0.99**	0.01		
CFI=0.94, GFI=0.65, χ^2=845.53, df=100				

Table A-4. The CFA of innovative culture.

Indicators	MLE estimate parameter		composite reliability (CR)	average variance extracted (AVE)
	indicator loadings (λ)	indicator error variances (δ)		
First level – Innovative culture				
C1 Encourages staff to generate new ideas			*0.81*	*0.68*
C11 Your company encourages employee creativity and innovation.	0.77**	0.41		
C12 Your company is good at new ways of doing things.	0.88**	0.23		
C2. Accepts new ideas			*0.80*	*0.58*
C21 Your company's staff can control their employees innovative activities.	0.80**	0.37		
C22 All the departments of your company emphasize teamwork.	0.87**	0.23		
C23 Your company assigns a high degree of responsibility to managers.	0.58**	0.67		
C3. Staff are authorized staff to make decisions			0.77	0.61
C31 Your staff will explain the reasons for their decisions.	0.75**	0.44		
C32 Your company allows employees to work their own way.	0.57**	0.68		
C33 Your company will improve the mutual communication between various departments.	0.81**	0.34		
C34 You company can authorize decision-making among lower-level workers.	0.54**	0.71		
C4. Encourages staff to communicate with each other			0.75	0.51
C10 Your company makes decision from a long-term view, even if the short-term cost will be higher.	0.60**	0.64		
C11 Your company has an evaluation system to measure the performance of each employee.	0.82**	0.33		
C12 Your company has more emphasis on performance rather on rules and procedures.	0.70**	0.50		
Second level – Innovative culture			0.92	0.76
Encourages staff to generate new ideas	0.81**	0.34		
Accepts new ideas	0.82**	0.33		
Staff are authorized to make decisions	0.92**	0.15		
Encourages staff to communicate with each other	0.92**	0.16		
CFI=0.89, GFI=0.79, χ^2=313.64, df=50				