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Key factors affecting technological capabilities in small and medium-sized Enterprises in Taiwan

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Abstract

Technological capability is a core resource and distinctive competency that enables firms to create firm value. With greater technological capability, firms have more unique resources and skills and engage in more strategic activities and thus can gain competitive advantages and increase their profitability while enhancing their organizational performance. However, small and medium-sized enterprises (SMEs) invariably lack resources required to develop technological capabilities. This study explored the determinants of improvements to technological capabilities based on data regarding SMEs in Taiwan. By following this line of literature, we developed a structure with five independent constructs ("Knowledge Sharing," "Talent Train," "Cooperative Relationships," "Innovation," and "Government Support") and one dependent construct ("Technological Capabilities"). We conducted multiple correspondence analysis (MCA) to analyze data collected from questionnaires issued to 77 manufacturing SMEs in Taiwan. MCA can map variables and individuals and therefore enables the construction of complex visual maps and the interpretation of their structures. The findings of this study revealed that technological capabilities can improve firm performance.

Keywords Small and medium-sized enterprise · Technological capability · Multiple correspondence analysis

Introduction

Taiwan's small and medium-sized enterprises (SMEs) are the primary driving force behind the country's national economic development. In particular, SMEs play a key

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role in sustaining economic growth, providing jobs, and developing industries (Hu and Chi 1998). As of 2017, SMEs accounted for 97.7% of all Taiwanese companies and provided 78.44% of employment in Taiwan, thereby playing a central role in the country's economy. In addition, data have shown that 79.85% of Taiwan's SMEs belong to the service industry. Moreover, almost half (47.93%) of Taiwan's SMEs are in the wholesale and retail industry. Most Taiwanese SMEs are family businesses. The ratio of Taiwanese SME employers over the age of 50 years is 53.45%, and the corresponding ratio over the age of 60 years is 17.04%. Hence, Taiwanese SMEs are facing pressure to find a new method of survival. SMEs differ from large organizations primarily in terms of SME characteristics such as resource limitations, informal strategies, and flexible structures (Shuman and Seeger 1986). To compete in Taiwan's rapidly changing environment, the country's SMEs must concentrate on growth, performance enhancement, and firm survival. Over the preceding decade, the manufacturing exports and sales ratios of SMEs have been the highest among all industries in Taiwan. Manufacturing remains the most common element of Taiwan's industrial structure. However, recent years have seen many factors that have caused Taiwan's manufacturing industry to shift from being labor-intensive to technology-intensive and capital-intensive; these factors include labor shortages, increasing wages, and competition from emerging economies in Southeast Asia.

To achieve continuous growth and a unique level of competitiveness, SMEs must accumulate their knowledge to develop technological capabilities. The Taiwanese government has started to promote the development of SMEs' technological capabilities for the purpose of accelerating the transformation of industries from labor-intensive to technology-intensive industries (Lin and Lin 2012). Hence, the present study explored the determinants of improving technological capabilities by using data regarding Taiwanese SMEs. SMEs invariably consider how to acquire knowledge and use technology more efficiently with their existing resources. Firms can acquire technology through two channels: the development of internal resources and the acquisition of resources through external sources (Friar and Horwitch 1985). Technological capability is a core resource and a distinctive competency for firms that enables the creation of firm value. With greater technological capabilities, firms may possess more unique resources and skills and engage in more unique strategic activities. These aspects enable firms to gain competitive advantages and increase their profitability while enhancing their organizational performance (Höflinger et al. 2018; Maximova et al. 2019). SMEs are currently facing a business environment where new technological firms are rapidly changing and where the number of competitors is increasing. However, SMEs are unable to independently create sufficient power through knowledge. Therefore, cooperation with external organizations to access technology is recommended. Wilderman (1998) and Lambe and Spekman (1997) have indicated that the efficient acquisition of external knowledge and technology is a key source of competitive advantages. If SMEs can gain further competitive advantages, reinforce their organizational resources and capabilities, and create distinctive competencies, their performance will be enhanced.

Technological capability provides products and services, increases a company's market share, enables the achievement of financial goals, and provides determinants for how to maintain one's business. Technology not only plays a key role in industrial competition (Zahra and Bognerb 2000) but also is the primary factor influencing a firm's competitiveness. Furthermore, technology is a necessity for gaining competitive advantages and access to new markets (Becheikh et al. 2006). Taiwan's SMEs are continuously involved in the creation of a competitive industrial structure to improve public and private technological development. The idea behind the country-led industrialization of manufacturing SMEs is to establish technological competence (Wade 1990). The present study explored and reviewed key factors affecting SMEs' development of technological capabilities. This study employed multiple correspondence analysis (MCA) to analyze collected data. A total of 509 Taiwanese firms were selected for analysis through a random sampling method.

Conceptual background

A literature review of studies regarding technology in relation to manufacturing SMEs revealed that many sources on this subject are available. By following this line of research, we first eliminated all articles where methodological standards were not rigorously adhered to (Flynn et al. 2004). We searched online databases and article reference lists to identify published articles regarding the technical development of SMEs. Our primary source of information to identify studies eligible for this review was the EBSCO database. Our search keywords included "small and medium-sized enterprises," "technology," "capabilities," and "innovation." Based on a comprehensive overview, we developed a structure with five independent constructs and one dependent construct (Whetten 1989). The potential impact of each construct is discussed in this paper before the research design is detailed.

Knowledge sharing

Technology must be developed to absorb, transfer, and share knowledge among firms; such technology requires SME employees to be willing to share and combine their knowledge and experience with one another (Gatarik 2019). Such willingness could help employees to absorb knowledge from both internal and external environments and to create firm value for application (Dyer and Nobeoka 2000; Gray 2001; Audretsch and Link 2019b). A firms' knowledge comprises individual and group knowledge that is shared among all members of said firm (Grant 1996). In SMEs, knowledge sharing can help to overcome limited technological capability and facilitate the use of generated knowledge. Through knowledge sharing, firms can obtain further information, ideas, and understanding regarding customer needs and can subsequently apply these commodities to improve firm capabilities. Many empirical studies have demonstrated that managing and sharing knowledge can benefit multiple areas of a firm and have emphasized that the creation and combination of new knowledge are key elements for enhancing technological capability in SMEs (Kogut and Zander 1992; Benavides-Espinosa and Roig-Dobón 2011). Furthermore, knowledge sharing has the power to inspire organizational creation and facilitate adaption to technology (Liebowitz 2001). At present, knowledge is considered a useful tool for improving a firm's technological capabilities (Zaim et al. 2007; Pérez-López and Alegre 2012). The establishment of a knowledge-sharing environment is a beneficial measure for SMEs; such intensive efforts help to determine resources required to improve technology capability.

Talent training

The key factors that enable SMEs to increase their technological capabilities are workers' technical education and prior work experience and investment in research and development (R&D) and training (Romijn and Albaladego 2002). Previous studies have revealed that the implementation of training programs in firms can result in considerable gains (Bartel 1994) and that maintaining competitiveness is vital for firm growth (Mital 1999). Muscio (2007) demonstrated that workers are the foundation of organizational capital and contribute to an SME's overall learning capacity for absorbing new technology. Entrepreneurs are increasingly realizing the importance of well-trained workers, engineers, and managers for the development of technology in SMEs. Well-trained workers learn and absorb new technology more efficiently than do non-well-trained workers. Furthermore, training programs can enhance workers' cognitive abilities to adapt to nonroutine tasks. Hence, many firms effectively promote technological development through formal training (Sandulli et al. 2013). Training not only enhances workers' professional capabilities but also improves their professional attitudes and motivation. In addition, training better facilitates technological development in SMEs than does hiring highly skilled workers. Overall, training facilitates the acquisition of new skills and the improvement of existing skills and should be considered a key policy for firms (Carnevale and Goldstein 1990).

Cooperative relationships

SMEs need to collaborate because they lack resources and have limited capital compared with larger firms. Technological collaboration can help to overcome these limitations (Rogers 2004; Nooteboom 1994). This study defined a cooperative relationship as a firm cooperating with another firm to develop technological capabilities. The Taiwanese government encourages firms in Taiwan to cooperate with other firms to improve their technological capabilities. Nieto and Santamaría (2010) indicated that in addition to technological cooperation being a useful method for firms of all sizes to improve their existing technology, such cooperation is also a key factor for the smallest of firms. When enterprises cannot obtain required resources from their internal environments, they must engage in other strategies such as exchanging with other firms (Lambe and Spekman 1997; Pan et al. 2018), learning from other firms (Schroeder et al. 2002), establishing long-term relationships with partner firms, and importing external complementary technologies and resources (Huang et al. 2009; Talay et al. 2009). If an enterprise can broaden the scope of its technology, it may share its existing technology with other firms as a form of cooperation. Every enterprise has a unique set of resources; therefore, an enterprise that cooperates with other enterprises can generate more profit than can one that operates independently of all others (Dyer and Singh 1998). Complementary technology refers to when cooperating partners share valuable and unique technologies with each other; such technology is beneficial in terms of an enterprise enhancing its existing technology (Hill and Hellriegel 1994; Sarker et al. 2001; Huang et al. 2009). Tsai and Wang (2009) believed that cooperation with other firms can improve an enterprise's technology, promote its development of professional capabilities, and reduce its level of investment in technological innovation. In summary, SMEs should consistently attempt to acquire and share new technologies to improve their professional capabilities.

Innovation

Many studies have demonstrated the importance of SMEs, especially in developing and emerging economies. Nowadays, competitive SMEs must consider how to maintain their development, as well as their responses to the demands of their environments (Roxas 2008). Howell (2005) indicated that innovation is a key factor in developing and sustaining economic growth in SMEs. Schumpeter (1934) believed that innovation is a production function to improve output and therefore can generate new technology while improving existing technology. SMEs have inherent advantages in terms of achieving technological innovation, including a simple organizational structure, open internal communication, high focus, quick decision-making capabilities, and high flexibility (Krishnaswamy et al. 2010). SMEs use different pathways of technological innovation from those of large firms (Fritsch and Meschede 2001; Nooteboom 1994). Large firms often innovate through outsourcing, whereas SMEs tend to innovate independently (McKelvie and Wiklund 2010). Consequently, SMEs must engage in innovation and R&D to improve their technology capability, develop new markets, and maintain growth in the current competitive environment (Love and Roper 2015).

Government support

To encourage SMEs in the field of industrial technology to engage in applied R&D, the government has begun to promote the "Industrial Technology Development Program" for SMEs. Because SMEs lack the resources to invest in R&D, government grants are being issued to fund technological development programs that can been efficiently implemented with a view to assisting SMEs in developing technology-intensive businesses (Audretsch and Link 2019a; Hsu and Chiang 2001). Because of this funding, SMEs can reduce their costs and share risks while retaining their R&D results. In many countries, government-sponsored improvements to technology programs have proven helpful for encouraging SMEs to engage in technological projects. Some evidence suggests that governments are supporting SMEs for technological improvement. In South Korea, the government has implemented multiple policies to support SMEs, including the "technology roadmap" program for the improvement of SMEs' R&D activities and technological capabilities; thus far, the results have revealed success (Jun et al. 2013). Furthermore, governments worldwide have played key roles in building successful technological consortia in competitive countries (Mathews 2002). Branstetter and Sakakibara (2002) observed that enterprises frequently participating in government-sponsored research consortia has a positive effect on research productivity.

Methodology

A questionnaire was designed for this study based on multiple measurement items and a literature review. Eighteen variables were developed to measure "Knowledge

Sharing," "Talent Training," "Cooperative Relationships," "Innovation," and "Government Support." After the questionnaire had been designed, it was sent to selected experts for validation and modification. A pretest was also conducted. We focused only on SMEs in central Taiwan. The dataset was collected from government publications. An original sample size of 5090 companies was obtained. A total of 509 firms were randomly chosen by selecting every tenth firm from the dataset. The questionnaire was sent to the owner of each SME in April 2016. A total of 73 valid questionnaire responses were obtained, yielding a response rate of 14.3%. We conducted MCA to analyze data collected from the returned questionnaires. Everitt and Dunn (2001) defined MCA as an extension of correspondence analysis. MCA is used to analyze observations described by nominal variables and can analyze multiple categories of variables simultaneously; it is also known as homogeneity analysis (Leong et al. 1998; Esmaelian et al. 2017). Hoffman and de Leeuw (1992) formulated MCA as a nonlinear multivariate analysis method that integrates ideas from multidimensional scaling.

Empirical results

Table 1 shows the basic numerical results of MCA, which can be applied to obtain lower dimensional representations of categorical data. This study had 18 variables (dimensions) and made 73 observations. Based on the measures determined using MCA (Table 1), we were able to calculate the corresponding eigenvalues and their correlations (Table 2).

If the eigenvalue of dimension 1 of a variable was higher, the said variable was assigned to dimension 1, and vice versa. "Knowledge Sharing," "Training Method,"

Table 1 Eigenvalues for each variable in dimensions 1 and 2

Variable	Dimension 1	Dimension 2
Knowledge sharing	0.424	0.053
Knowledge acquisition	0.083	0.201
Increase understanding	0.000	0.018
Training method	0.337	0.058
Training time arrangement	0.040	0.149
Training category	0.451	0.259
The best training method Interference with operations Motivation for	0.451	0.279
cooperation	0.087	0.123
Reasons for cooperation	0.541	0.076
Cooperation period	0.522	0.230
Number of firms in your network	0.169	0.127
Innovation category	0.046	0.094
Innovation activity	0.372	0.276
Type of process	0.613	0.279
Government sponsorship	0.055	0.208
How to operate project	0.335	0.039
Government support method	0.064	0.162
	0.007	0.326
Eigenvalue	0.275	0.164

Table 2 Number of firms in each region based on industrial classification

Industry Classification	I	II	III	IV	Total
Semiconductors/Communications/Electronic	5	1	3	9	18
Metal/Hardware	5	4	4	2	15
Machinery/Computer Peripheral Equipment	3	1	3	0	7
Plastics Products	2	0	0	1	3
Medical Instruments	1	1	0	1	3
Auto Parts & Bicycles Parts	0	0	1	1	2
Steel Works	0	0	0	2	2
Textile Mill Products	0	0	1	0	1
Food Products	0	0	0	1	1
Retail Stores	4	1	1	4	10
Consulting, Accounting, Research	0	3	4	4	11
Number of Firms	20	11	17	25	73

"Training Category," "The Best Training Method," "Motivation for Cooperation," "Reasons for Cooperation," "Cooperation Period," "Innovation Category," "Innovation Activity," and "Government Sponsorship" were classified under dimension 1. Dimension 2 comprised "Knowledge-Sharing Acquisition," "Increased Understanding," "Training Time Arrangement," "Interference with Operations," "Number of Firms in Your Network," "Type of Process," "How to Operate the Project," and "Government Support Method". Figure 1 shows the discriminatory measurements.

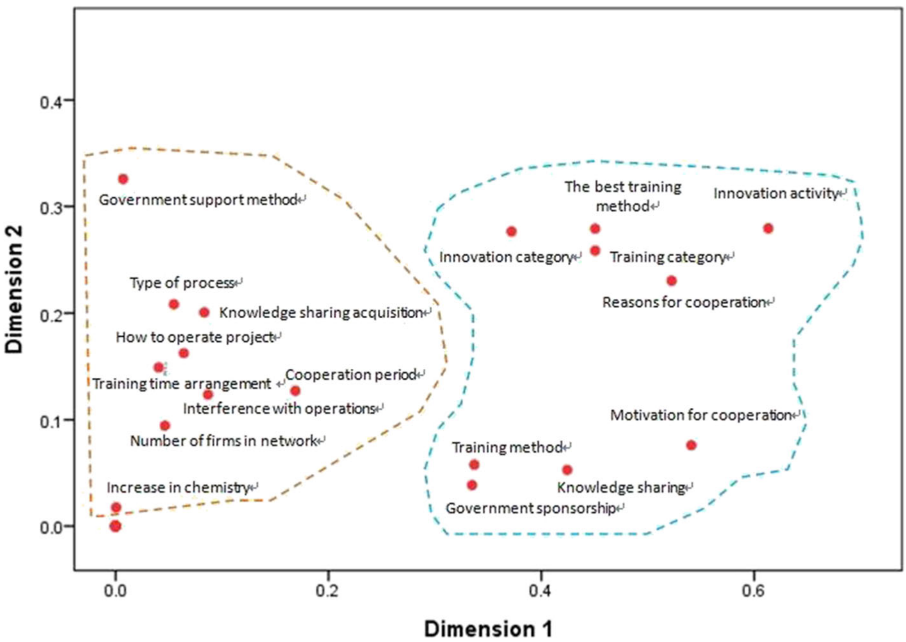

Fig. 1 Discriminatory measurements

Dimension 1 was named "Learning and Growth." The firms near the right of the horizontal axis had more significant learning and growth and were relatively similar to one another; by contrast, firms near the left of horizontal axis had insignificant learning and growth and were less similar to one another. Dimension 2 was named "Technical Collaboration." The firms near the top of the vertical axis demonstrated stronger technical collaboration and were relatively similar to one another; by contrast, the firms near the bottom of the vertical axis demonstrated weaker technical collaboration and were less similar to one another.

Figure 2 depicts distances between firms. Two firms close to each other in terms of distance had similar levels of development for technological capability. The firms in the yellow circle were highly similar in terms of knowledge sharing, training method, training time arrangement, the best training method, interference with operations, motivation for cooperation, reasons for cooperation, cooperation period, innovation activity, type of process, government sponsorship, and how to operate the project. We divided the firms in Fig. 2 into four categories to show the relationship of learning and growth with technical collaboration (Fig. 3).

I: Significant learning and growth + high-strength technical collaboration The firms in this region were more active in terms of innovation activities, training categories, and training methods. These firms cooperated with other firms to access knowledge. In addition, they had relatively high significant learning and growth and high-strength technical collaboration, usually obtained sponsorship from the government, and always implemented the project with the lowest risk. These firms demonstrated outstanding

Fig. 2 Quantification chart

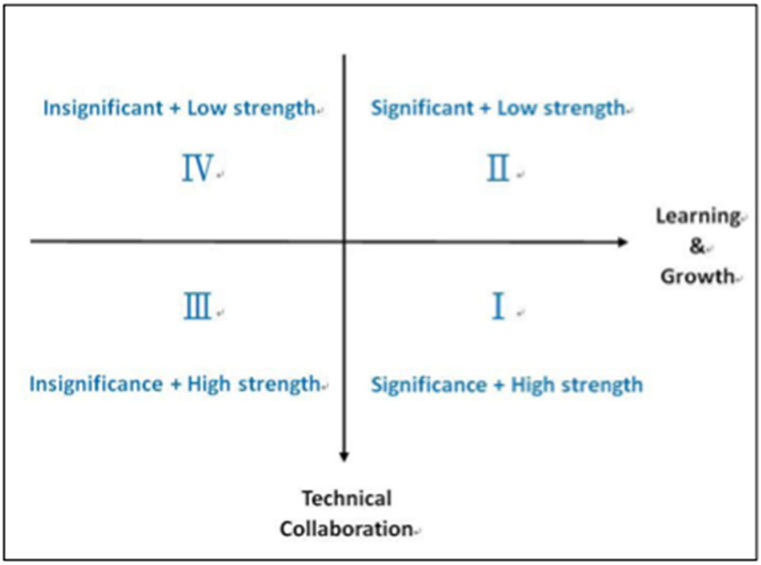

Fig. 3 Classification chart

performance in terms of “Knowledge Sharing,” “Education and Training,” “Cooperative Relationships,” “Innovation,” and “Government Support.”

II: Significant learning and growth + low-strength technical collaboration The firms in this region tended to learn and engage in many innovation activities independently and had many innovation categories. In addition, they paid much attention to their employee training programs. Although they did not obtain sponsorship from the government, they continued to run projects independently. Furthermore, they considered internal development more important than cooperation with other firms. Firms in this category had high significant learning and growth but low-strength technical collaboration. They could enhance their “Knowledge Sharing” and “Cooperative Relationships” to improve their technological capability and in turn enhance their performance.

III: Insignificant learning and growth + high-strength technical collaboration The firms in this region tended to share knowledge with other firms to obtain the knowledge they required. These firms expected the government to provide support to help them to minimize their internal R&D expenditure. These firms used internal and external resources to produce innovative products. In addition, they exhibited relatively insignificant learning and growth but high-strength technical collaboration. These firms could enhance their “Innovation” and “Education and Training” capabilities to improve their weaknesses in learning and growth.

IV: Insignificant learning and growth + low-strength technical collaboration The firms in this region engaged in fewer innovation activities and cared relatively little for their employees, who must enroll in training courses in their free time. In addition, these firms do not encourage cooperation with other firms. They have low motivation to operate projects if they cannot obtain sponsorship from other firms. Thus, these firms have relatively insignificant learning and growth and low-strength technical collaboration. These firms could learn "Innovation," "Cooperative Relationships," and "Government Support" from region I to enhance their technological capabilities.

Conclusion

In this study, we applied MCA to divide variables into two dimensions. Dimension 1 was named "Learning and Growth," and dimension 2 was named "Technical Collaboration." We plotted a quantification chart to view interrelationships between variables and observations. Most of the firms were located in regions III and IV. The firms in region I had the most favorable performance. Thus, the firms in regions III and IV are recommended to follow the strategies of the firms in region I. The firms in region I offered competitive employee benefits and provided training programs to educate employees in areas such as R&D, new technology, logistics management, and customer service. Several benefits are associated with training, including consistent job performance, high job satisfaction, high customer satisfaction, and low expenditure (Wesley and Skip 1999). Furthermore, the firms in region I engaged in innovative activities. They held regular meetings to discuss how to improve the manufacturing and service processes. Most of their innovative activities focused on developing new techniques related to machinery, equipment, and software. In addition, to reduce expenditure and uncertainty, enhance competitiveness, increase the elasticity of operations, and respond to customers quickly, these firms tended to cooperate with other firms and share their knowledge to improve their own capabilities. In Taiwan, the government plays a critical role in encouraging SMEs to become actively engaged in R&D for innovative applications and services. These government-sponsored projects help SMEs to reduce their expenditure and risk when engaging in innovative and R&D activities. Moreover, the Taiwanese government sponsors SME training programs to help SMEs develop their own capabilities.

According to the resource-based view theory, technology enhances competitiveness and firm performance. The sharing of SME technologies is widely viewed as a means of stabilizing competitive advantages and thus enhancing firm performance (Koc and Bozdag 2009). In addition, some evidence suggests that SME performance is positively associated with the development of internal technological capability (Maranto-Vargas and Gómez-Tagle Rangel 2007). Taiwan's industrial structure is highly dependent on the manufacturing industry, and the country's economic development has already exhibited success, particularly in terms of technological development. Technology is the final product of the manufacturing sector and provides middle input for production and initial knowledge for accumulation. Technological capability is a key factor in maintaining or enhance SMEs' competitive advantages. Based on the literature review conducted in this study, we propose that the constructs of "Knowledge Sharing," "Talent Train," "Cooperative Relationships," "Innovation," and "Government Support" are critical for improving a firm's technological capability.

Appendix

Table 3 References for each construct

Construct	Variable	Reference
Knowledge Sharing	Knowledge sharing Knowledge acquisition Increase understanding	Gatarik 2019; Dyer and Nobeoka 2000; Gray 2001; Audretsch and Link 2019b; Grant 1996; Kogut and Zander 1992; Liebowitz 2001; Zaim et al. 2007; Pérez-López and Alegre 2012
Talent Training	Training method Training time arrangement Training category The best training method	Romijn and Albaladego 2002; Bartel 1994; Mital 1999; Muscio 2007; Carnevale and Goldstein 1990
Cooperative Relationships	Interference with operations Motivation for cooperation Reasons for cooperation Cooperation period Number of firms in your network	Rogers 2004; Nooteboom 1994; Nieto and Santamaría 2010; Lambe and Spekman 1997; Pan et al. 2018; Schroeder et al. 2002; Huang et al. 2009; Talay et al. 2009; Dyer and Singh 1998; Hill and Hellriegel 1994; Sarker et al. 2001
Innovation	Innovation category Innovation activity Type of process	Roxas 2008; Howell 2005; Krishnaswamy et al. 2010; Fritsch and Meschede 2001; Nooteboom 1994; Love and Roper 2015
Government Support	Government sponsorship How to operate project Government support method	Audretsch and Link 2019a; Hsu and Chiang 2001; Jun et al. 2013; Mathews 2002; Branstetter a nd Sakakibara 2002

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