

The antecedents of innovation performance: the moderating role of top management team diversity

Moderating
role of TMT
diversity

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Abstract

Purpose – The purpose of this paper is to investigate why firms engaged in R&D investment and international diversification produce different results in innovation performance.

Design/methodology/approach – This study is based on a sample of 283 Taiwanese manufacturing firms in the information technology industry.

Findings – The findings showed that in the top management teams (TMTs) with greater tenure diversity there was a stronger relationship between R&D investment and innovation performance. In addition, the TMTs with greater educational diversity enhanced the relationship between international diversification and innovation performance.

Originality/value – This study stresses the vital role of TMT diversity in resource allocation and information processing during the process of innovation. The authors examined the critical role of TMT educational diversity in bringing a wider range of network resources and the role of TMT tenure diversity in the allocation of firm-specific resources. The TMT diversity causes firms to experience different innovation results during the innovation process.

Keywords Diversity, Top management team, International diversification, Innovation performance, R&D investment

Paper type Research paper

Introduction

Innovation is essential for firms to establish a competitive advantage and achieve superior performance (Hitt *et al.*, 1997; Zahra *et al.*, 2000). The factors that drive innovation performance and how firms generate economic returns from innovation have attracted a great deal of interest from researchers (e.g. Cao and Zhao, 2013; Inkien *et al.*, 2015). The existing literature has found that firms can innovate either by accessing ideas and knowledge externally by joining an alliance and cooperating with partners, or by exploiting internal capabilities through investment in R&D and foreign direct investment (Cui and O'Connor, 2012; Hsu *et al.*, 2015; Wang and Kafouros, 2009).

As regard the development of innovation performance through the exploitation of internal capabilities, prior studies have confirmed the positive influence of R&D investment and international diversification on innovation performance (e.g. Hsu *et al.*, 2015; Phene and Almeida, 2008). However, only a limited number of studies have examined “why” firms engage in R&D investment and how international diversification generates different results in innovation performance. The effective management of innovation performance during the innovation process is challenging because innovation is a long-term, accumulative and uncertain process (Buckley and Carter, 2004; Jansen *et al.*, 2006).

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Studies suggest that a lack of management ability may cause a firm to experience difficulties in achieving success and development in innovation (e.g. Alexiev *et al.*, 2010; Ruiz-Jimenez *et al.*, 2016). However, few studies have explored the role of the management capability possessed by the top management team (TMT) in the innovation process. According to the upper echelons theory, the top executive's background is relevant to their existing knowledge and skills, both of which influence their ability to recognize and identify innovative opportunities (Bantel and Jackson, 1989; Hambrick and Mason, 1984; Hambrick *et al.*, 1993). Studies have suggested that diverse TMTs offer higher information processing abilities to overcome uncertainty when assessing innovative sources during internationalization (i.e. Herrmann and Datta, 2005; Tihanyi *et al.*, 2000). Meanwhile, taking the resource-based view, diversified knowledge and capabilities provided by TMTs ensure a more effective allocation of resources when managing the innovative process through R&D investment (Kor and Mahoney, 2005). TMTs contribute to the development of routines, procedures and capabilities that affect the firm's growth and innovation (Kor and Mesko, 2013). Prior studies have shown that certain TMTs have the management ability to recognize external innovation opportunities and to coordinate organizational resources to develop innovation (Alexiev *et al.*, 2010; Jansen *et al.*, 2006).

Prior studies have claimed that the TMTs take a moderating role by recognizing distant opportunities and deploying their expertise and knowledge in managing complex activities and guiding resources in innovative activities (i.e. Kujala *et al.*, 2017; Li *et al.*, 2013). Diverse characteristics of the TMTs allow them to deploy internal resources and combine external information and knowledge when firms evaluate innovation sources (Rodan and Galunic, 2004). Alexiev *et al.* (2010) considered the importance of the role of TMT diversity to fuel the process of innovation, and take TMT diversity as a moderating role in managing the process of seeking advice to generate innovation. Ruiz-Jimenez *et al.* (2016) found that the TMT diversity enhanced the relationship between management capabilities and innovation. Mihalache *et al.* (2012) claimed that the TMT attributes in information diversity enhance the relationship between offshoring and innovation. Yuan *et al.* (2014) also stressed that the diversity of TMTs enhances the relationship between R&D investment and innovativeness.

In this study, we addressed the role of TMT diversity in providing an effective management ability and management mechanism that optimizes R&D investment and international diversification to prompt innovation performance. The study is based on a sample of Taiwanese technology/manufacturing firms because R&D investment and international diversification are two vital approaches for firms in these industries that allow them to tap into the global market and maintain their competitive advantage in the international market (Bartlett and Ghoshal, 1997; Kim and Ha, 2010; Luo and Tung, 2007). Diverse TMTs effectively managing complex activities and information from R&D investment and international diversification is essential for such companies.

We provide several contributions to the existing literature. First, the existing innovation literature examines the relationships among R&D investment, international diversification and innovation performance (e.g. Chen *et al.*, 2012; Kafouros *et al.*, 2008), but pays little attention to why firms engaged in R&D investment and international diversification produce different results in innovation performance. Prior studies have ignored the critical role of the diverse experience and knowledge of top managers, both of which fuel innovation performance, and studies indicate that TMT diversity in knowledge and experience facilitates innovation performance (e.g. Horwitz and Horwitz, 2007; Nielsen, 2010). To fill the research gap, we investigate the moderating role of TMT diversity in the relationship between R&D investment, international diversification and innovation performance. We highlight the important role of the top managers' management abilities in the superior development of innovation performance.

Second, we apply upper echelons theory and the resource-based view to address the role of the top managers' diversity in the innovation process to explore how TMTs with diverse experience and knowledge manage and assess the innovation process effectively. Third, unlike prior studies which only examined the direct influence of innovative sources on innovation performance, we suggest that the impact of R&D investments and international diversification is contingent upon two task-related characteristics in TMT diversity: educational diversity and tenure diversity. We acknowledge that TMT educational diversity indicates off-job knowledge which is associated with a greater ability to accept novel ideas and uncertainty, and to bring the social network. Tenure diversity represents an on-job knowledge which is associated with the ability to allocate resources effectively. Moreover, we emphasize the moderating effect of the top managers' diverse experience and knowledge in order to develop a greater understanding of how management ability affects the relationship between R&D investment, international diversification and innovation performance.

Following the introduction, the second section of this paper develops the research background of innovation performance. The research hypotheses are presented in section three. The fourth section describes the research method, and the fifth section states the empirical results and discussion. Finally, the conclusion section includes the contributions of this research, research limitations and suggestions for future studies.

Research background

In the stream of literature on the antecedents of innovation, studies have pointed out that firms can build innovation through external or internal development (Hitt *et al.*, 1997; Phene and Almeida, 2008). Firms can access innovative sources either by bridging technological abilities externally through R&D alliances (e.g. Sampson, 2007), cooperating with R&D partners (e.g. Oxley and Sampson, 2004), or by developing innovative abilities internally through R&D investment (Griliches, 1979; Hall and Bagchi-Sen, 2002) and engaging in international diversification (Hitt *et al.*, 1997; Wang and Kafouros, 2009).

The role of R&D investment and international diversification in innovation performance

R&D investment is identified as relevant to the innovation performance of a firm (Griliches, 1979). Firms can accumulate skills and build innovative abilities through R&D investment, which enhances a firm's ability to absorb new ideas and develop new technology (Filatotchev and Piesse, 2009; Zahra and George, 2002). Furthermore, Phene and Almeida (2008) claimed that R&D investment facilitates the assimilation of external knowledge and its integration into existing knowledge, which affects a firm's ability to innovate.

Upgrading technological abilities allows a firm to reduce the costs of production and management (Zahra and George, 2002). In addition, investing in R&D activities strengthens a firm's awareness of consumer demand, and stimulates the introduction of new products and the exploration of new market opportunities. R&D investment can develop tacit assets and reinforce existing abilities, which can counter competitive actions by rivals, and even preempt the competition (Kafouros *et al.*, 2008; Zhang *et al.*, 2007). This form of investment provides firms with better monopoly power in markets to compete with rivals and to gain superior performance (Ito and Pucik, 1993). R&D investment represents firms' continuous investment of strategic resources in the search for potential market opportunities, thus enabling a rapid response to environmental uncertainty. Prior studies have confirmed that investment in R&D contributes to firms' productivity performance and future growth (e.g. Penner-Hahn and Shaver, 2005; Phene and Almeida, 2008). Thus, R&D investment brings higher economic rents in innovation performance.

Aside from R&D investment, the prior literature demonstrates that international diversification creates advantages in innovation (Kotabe *et al.*, 2002). International diversification assists with mapping out innovation input opportunities and innovation

output opportunities (Collinson *et al.*, 2016). Geographic diversification helps firms source inputs at a lower cost. In addition, entering international markets enables firms to access innovative sources and source local knowledge, thus facilitating increased innovation performance (Almeida and Phene, 2004; Song and Shin, 2008). For example, exploiting innovative resources, such as strategic talents and local research affiliations, will enhance a firm's competitive ability (Davis and Meyer, 2004). Since firms gain input innovation opportunities through internationalization, some firms adopt asset augmentation strategies to acquire strategic assets in the foreign market. Allocating and utilizing innovative resources through international diversification allows firms to generate innovative outcomes more effectively (Makino *et al.*, 2002; Kotabe, 1990).

Some firms exploit their specific advantages in the foreign market and utilize ownership strategies to explore the local market. Accessing clients in a host country enables firms to directly assess the product market, better understand the customers' needs and comprehend the competitive environment. Meanwhile, developing local networks to connect with foreign partners allows firms to gain the positive knowledge spillover effect (Davis and Meyer, 2004). Therefore, firms can acquire more knowledge from the local environment, which will stimulate innovation. Further output innovation opportunities in the foreign market are explored when firms apply innovative outcome in different foreign locations (Hitt *et al.*, 1997; Wang and Kafouros, 2009). Therefore, companies can improve their innovative capabilities by evaluating strategic assets, studying foreign markets and applying the resulting innovative performance to different foreign markets. In sum, progress in international diversification can enhance innovation performance.

The role of TMTs' diversity

The TMTs employ their abilities to manage resources and process the information to prompt innovation (Hoskisson *et al.*, 1993; Ruiz-Jimenez *et al.*, 2016; Umans *et al.*, 2018; Yoshida *et al.*, 2014). Through the management of complex activities and information, the top executives help to identify market opportunities and transfer the resources gained from R&D investment and international diversification.

The essential role of the top managers in managing the innovation process can be divided into two aspects: the ability to manage resources and the ability to process information. According to the resource-based view, the top managers' knowledge and experience allow them to manage the complex information and activities effectively and enable efficient utilization of resources when investing in R&D activities (Kor, 2006). The literature argues that the managers' experience helps them to find opportunities for the firm (Penrose, 1959).

According to the upper echelons theory, the characteristics and the background and experience of the top managers shape the managers' approach to decision making and selection of strategies (Hambrick and Mason, 1984). The executives' abilities and willingness to tolerate complexities and uncertainties in solving problems vary according to their prior knowledge and experience. In particular, the diverse knowledge and experience possessed by managers are beneficial in opening communication and providing a comprehensive assessment of possible innovative investments (Umans, 2008). A diverse TMT can effectively evaluate multiple options to resolve complicated issues, while their information processing abilities are associated with a firm's innovation performance (Certo *et al.*, 2006; Milliken and Martins, 1996).

Functional diversity, educational diversity, tenure diversity and international experience are widely recognized in prior studies as task-related characteristics of TMTs. In this study, we examine the different experience gained from off-job and on-job experience. Educational diversity is a more accurate means of capturing the features of off-job knowledge and experience. In addition, compared to functional diversity and international experience, tenure diversity is more relevant to the experience within an individual company. More specifically, TMT tenure is

related to a shared experience, common understanding and the knowledge accumulated and developed between the team members, which is specific to a team (Barkema and Shvyrykov, 2007). TMT tenure therefore can represent on-job knowledge and experience in this study.

The advantages of educational diversity and tenure diversity offer different ways to affect innovation performance when firms engage in R&D investment activities and international diversification. Educational diversity is related to the learning experience gained before the current task. Diverse experience accumulated from previous education training enhances the executives' open mindset, allowing them to accept new ideas and concepts (Bantel and Jackson, 1989). The executives with higher educational diversity have higher information processing capabilities to cope with the uncertainties and complexities of managerial tasks. In addition, a prior heterogeneous education experience provides executives with a broader social network, thus strengthening the executives' ability to access external innovative resources to their firms.

On the other hand, TMT tenure diversity represents reduced interaction and familiarity between the executives, which also reflects the difference in mutual understanding and asymmetries between the members. New members interacting with senior members of the TMT may increasingly adopt the knowledge, ideas and expected behaviors of the team (Erickson, 1988). Shared knowledge and mutual understanding of the task created by the team members may result in the development of similar thinking over time. Thus, the low interaction and experience of the diverse tenure TMT leads to a lower likelihood of sharing knowledge and developing a consensus. In addition, the reduced assimilation of the members leads the team members with broader capabilities to learn and to develop a different awareness and judgment regarding information from the external environment and the resources of the organization. The TMTs with a higher diversity of tenure thereby possess a better capability of incorporating market opportunities and the organization's resources. A lower common understanding and wider perspectives on the task will be established in a heterogeneous tenure team (Katz, 1982). Furthermore, a heterogeneous team approaches information processing and decision making differently than a homogeneous team since the approach of a diverse tenure team is based on a diverse set of values, experiences, beliefs and preferences possessed by the members. Thus, such a team tends to provide and generate more novel ideas (Barkema and Shvyrykov, 2007).

Although several studies recognized the positive impact of diverse TMTs on innovation, other studies pointed out the mixed findings on the impact of TMT diversity on strategic decision making and performance (Nielsen, 2010; Ruigrok *et al.*, 2013). Studies suggest that diversity may have adverse effects on innovation, such as interpersonal conflicts (Pelled *et al.*, 1999; Smith and Tushman, 2005). Conflicts resulting from diverse values and backgrounds may hinder the information sharing process and increase communication costs, thereby decreasing innovation (Bunderson and Sutcliffe, 2002; Simons *et al.*, 1999).

However, our study differs from the assumptions of prior empirical studies of western-developed countries, since we focus solely on Taiwanese companies, which are based upon Confucian ethics; therefore, they value consensus and harmony in collective decision making (Hofstede, 1980). The existing empirical evidence sampled from firms in developed countries revealed a high likelihood of interpersonal conflicts between top managers, which might not appear in countries with a Confucian ethical system. Thus, in this paper, we propose that the positive effect of TMT diversity enhances the relationship between innovation sources and innovation performance.

Hypotheses development

The moderating effects of TMT diversity on R&D investment and innovation performance

Prior research has demonstrated that a firm's investment in R&D activities contributes to its innovation performance (e.g. Green, 1995; Masso *et al.*, 2013). A greater emphasis on R&D

investment may lead to better innovation performance (e.g. Cardinal and Hatfield, 2000). However, investing in R&D activities also signals that a firm is willing to sacrifice its short-term returns for the sake of long-term growth and performance (Mansfield, 1986). Time-consuming and costly R&D investment may cause a variety of unexpected outcomes. R&D investment activities require professional knowledge from the managers to manage the possible risks and uncertainties effectively.

TMTs with diverse educational backgrounds and experience are more open to accepting new information and knowledge generated from R&D investment. A variety of educational experiences provide executives with a greater tolerance of ambiguity, and the ability to accept failures in an uncertain innovative process (Daellenbach *et al.*, 1999; Talke *et al.*, 2010), which encourages the executives to make long-term resource commitments and supports the transformation of innovative investment into innovation performance.

Prior studies have stated that the diverse training experience absorbed from the period of study strengthens the management's ability to manage and coordinate resources properly during the innovation development process (Yadav *et al.*, 2007). Therefore, the diverse knowledge background of TMTs provides a critical basis for the evaluation of innovative options and the assessment of innovative resources, which leads to a positive innovation outcome. Thus, a TMT with a greater diversity of backgrounds may reinforce the relationship between R&D investment and innovation performance:

H1a. The positive influence of R&D investment on a firm's innovation performance is reinforced by greater educational diversity in its TMT.

Executives with diverse tenure display different cognitive structures and awareness of new environments. Heterogeneous tenure also guides executives by providing a variety of perspectives to identify possible innovative opportunities from the R&D investment activities. Thus, a highly diverse tenure can facilitate the introduction of novel ideas from the R&D investment into innovation performance.

In addition, the transformation of R&D investment into innovation performance relies on a firm's ability to integrate new knowledge into its current organization (Cohen and Levinthal, 1989). In a diverse tenure team, the new team members will possess a powerful ability to identify different kinds of resources and information related to R&D activities from the external environment, and the senior executives will have a higher awareness of the internal organization's resources. Such a composition of executives can integrate novel external initiatives into an organization and transfer R&D investment resources effectively. The heterogeneous team is able to acquire external information and knowledge from a variety of sources and access resources across the firm's departments (Rodan and Galunic, 2004).

Moreover, prior studies have found that TMTs with diverse tenure are better prepared for the allocation of internal resources to R&D activities and the external environment, which brings complementary external resources to an organization and prompts innovation (Alexiev *et al.*, 2010). Such suggestions provided by the executives can guide firms to allocate resources carefully for innovative activities, thereby reducing unnecessary expenses and risks (Dalziel *et al.*, 2011):

H1b. The positive influence of R&D investment on a firm's innovation performance is reinforced by a greater tenure diversity in its TMT.

The moderating effects of TMT diversity on international diversification and innovation performance

International diversification generates innovation input opportunities and innovation output opportunities for firms (Collinson *et al.*, 2016). Educational diversity provides a TMT with a broader range of knowledge and information sources to identify innovative opportunities

from the international market than a more homogeneous TMT. Prior studies have also proved that the diverse education training experience improves the executives' confidence in their ability to overcome uncertainties and risks in the process of internationalization due to their possession of a wider range of professional skills (Carpenter and Fredrickson, 2001; Herrmann and Datta, 2005). Diversity allows the executives to face uncertainty while remaining involved in innovative inputs from the international market, thus enhancing the firm's innovation performance (Jahanshahi *et al.*, 2018; Wiersema and Bantel, 1992).

In addition, a top executive team with a greater educational diversity brings more social capital and external networks resources from their prior study experience (Ancona and Caldwell, 1992). Wider social networks provide more external clues, information and advice through which TMTs verify and evaluate potential new opportunities gained from foreign markets. Moreover, social networks supply external connections to access related resources and knowledge, which assists with the organization of information acquired from customers and relevant business intelligence (Athanasiou and Nigh, 2002). The TMTs' external broader connections provide unique information flows connected to potential external advice from the team members' varied expertise, thus enhancing the members' abilities to identify novel strategic solutions from foreign markets (Ndofor *et al.*, 2015). In addition, engagement in international diversification strengthens the firms' ability to assess foreign customers, and creates an opportunity for innovation output. Executives with diverse social networks bring more foreign customers to the firm, and can update the company's technology to fulfill the required specifications of foreign customers, thus improving innovation performance:

H2a. The positive influence of international diversification on a firm's innovation is reinforced by a greater educational diversity in its TMT.

International diversification provides an opportunity for firms to obtain additional information sources from foreign countries. Many firms also tend to build innovative capabilities through R&D internationalization to gain strategic assets (Hitt *et al.*, 1997), such as local talent, to improve a firm's innovative capacity (Cheng and Bolon, 1993). Identifying new market opportunities internationally and exploiting accessible resources contribute a firm's success in international markets (Jones and Coviello, 2005).

The lower level of assimilation between the team members of a diverse tenure TMT enables the team to assess and integrate information and innovative resources from the foreign market from multiple perspectives. The variety of perspectives and task experience they possess allow the executives to exploit specific assets or implement asset argumentation strategies acquired from the international market based on multiple perspectives (Buckley *et al.*, 2016). Compared to homogeneous tenure TMTs, a diverse tenure TMT will show greater acceptance of a variety of information types and resources. A more open-minded attitude and multiple perspectives gained from foreign markets improve the firms' ability to bring new ideas into the organization and fuels the generation of a better innovation outcome.

Moreover, international diversification forces companies to face the challenge of complicated management tasks (Carpenter, 2002). The lower degree of common understanding and shared knowledge developed by the diverse tenure TMTs cause the executives to have different perspectives, which help them to integrate and to judge the possible uncertainties and complexities of foreign markets. When confronting a highly uncertain international environment, a team with diverse tenure can rely upon its members' different expertise and knowledge to respond to the risks and uncertainty caused by the various institutional, coordination and integration issues that occur when operating in different countries and cultures (Carpenter and Fredrickson, 2001). Hutzschenreuter and Horstkotte (2013) also found that TMTs with a greater diversity of tenure possessed higher information processing capabilities to cope with the complexities encountered during internationalization.

Meanwhile, when applying innovation output opportunities in a foreign market, a diverse tenure TMT has a greater ability to incorporate the organization's internal resources and identify external market opportunities. A better awareness of the individual demands from foreign markets and the ability to leverage internal resources effectively enables firms to provide a better innovative outcome for foreign markets. Thus, we propose the following hypothesis (Figure 1):

H2b. The positive influence of international diversification on a firm's innovation is reinforced by greater tenure diversity in its TMT.

Sample and data collection

We sampled from information technology firms in Taiwan, where high technology firms have been established to target overseas, highly internationalized markets. R&D investment and international diversification are two vital approaches for Taiwanese firms to tap into the global market and maintain competitive advantages in the international market (Hsu *et al.*, 2015). Prior studies have observed that R&D investment and international diversification are two strategies used by firms from small countries to seek growth and to gain competitive advantages (e.g. Kyläheiko *et al.*, 2011). Since such firms are usually latecomers to the global market, developing innovative and internationalized abilities will provide opportunities for them to catch up with competing firms in developed countries (Luo and Tung, 2007).

Taiwanese companies build upon competitive advantages based on a highly technological and internationalized orientation to serve global customers (Hsu *et al.*, 2013). Previous studies have indicated that R&D abilities are critical for enabling firms to generate improved innovation performance (e.g. Chen *et al.*, 2012). The majority of Taiwanese firms are merely links in a vast global supply chain and face fierce competition from larger international rivals; therefore, survival depends on continuous innovation through internationalization (Johnson *et al.*, 2009). R&D investment and increased access to international markets enable firms to upgrade their technological knowledge, acquire cutting-edge market technologies and strengthen their competitive positions (Santos *et al.*, 2004). For such firms, expanded R&D investment and entrance into foreign markets is a vital strategy, enabling them to exploit new business opportunities (Leonidou and Katsikeas, 1996).

A critical player in global value chains, the Taiwanese information technology industry engages more in innovative activities than other industries (Chen *et al.*, 2010). Therefore, we sampled from Taiwanese manufacturing firms in the information technology industry listed on the Taiwan Stock Exchange Corporation and the GreTai Securities Market in 2008 and 2009, and obtained 762 listed companies.

Innovation performance was measured by the number of patents that a firm applied for in 2009 and was collected from the Intellectual Property Office of Ministry of Economic Affairs in Taiwan. Considering that innovative inputs may have a lagged effect on

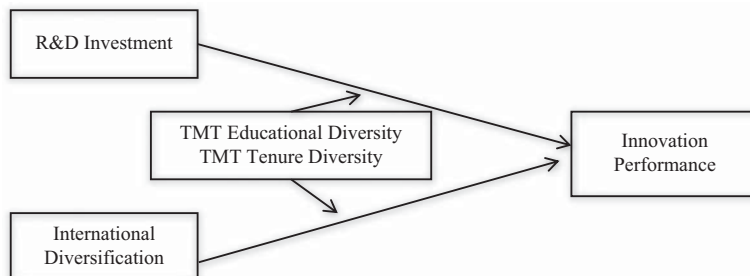


Figure 1.
Research framework

innovation performance, we adopted a lag of one year in the innovation performance of the independent, moderating and control variables. Our selection of a one-year lag is congruent with the theorized direction of the proposed hypothesized relationships and is broadly in line with past research (Hsu *et al.*, 2015; Phene and Almeida, 2008).

The R&D investment and other control variables were obtained from the Taiwan Economic Journal Data Bank. TMT diversity and international diversification were acquired from annual company reports. After excluding the companies with incomplete data and insufficient information about the TMT background in the annual reports and patent application, observations from 296 companies remained. In addition, a number of sample companies had registered considerably more patents than the average. Considering that the extremely high number of patents of outliers among the sample firms might affect the results, we excluded the 13 outliers outside three standard deviations for the innovative performance (Shiffler, 1988), leaving us with data from a total of 283 firms in the years 2008 and 2009 to use in the investigation of our developed hypotheses.

Measurements

Innovation performance is the dependent variable in this study, which represents an outcome of technological novelty and competitive position. We measured innovation performance as the number of patent applications filed in 2009. The patent reflects a company's technological indicators (Wang and Kafouros, 2009) and the use of patent applications to represent a firm's innovation performance has been widely applied in prior literature (Almeida and Phene, 2004; Stuart, 2000). Patents are recognized as demonstrating a firm's commitment to novelty and innovation (Walker, 1995). In addition, they create competitive advantages for firms, enabling them to fend off competition from rivals. Many studies have confirmed that the rate of patent application can be viewed as an aspect of the innovative performance of a firm (e.g. Henderson and Cockburn, 1996), while scholars have observed that the innovative outcome such as patents and new product development are highly related (Hitt *et al.*, 1997).

R&D investment determines the R&D know-how of a firm and creates intangible assets for a firm (Dierickx and Cool, 1989). Such investment is relevant to the capabilities to launch new products and to acquire knowledge (Bromiley 1991). In this study, R&D investment was measured by R&D intensity, which is the calculation of the ratio of research and development expenditures to a firm's total sales (Levin *et al.*, 1985). International diversification is a strategy through which a firm expands its products/services into different geographic locations or markets (Hitt *et al.*, 2006). It reflects a company's motivation to gain economies of scale, to access new resources and knowledge, to obtain cost reductions and location advantages and to extend innovative capabilities (Hitt *et al.*, 1997). Several measures of international diversification have been employed in previous research, such as the percentage of a company's total sales that are foreign sales (e.g. Autio *et al.*, 2000), the ratio of foreign assets to total sales of a company (e.g. Geringer *et al.*, 1989), the number of foreign countries where a company has a subsidiary (Sambharya, 1995) and the amount of a company's foreign direct investment (Delios and Beamish, 1999). Scholars have suggested using multidimensional measures to improve the validity of measuring the level of international diversification (Sullivan, 1994). In this study, we followed the method used by Sullivan (1994) to measure international diversification in three dimensions (the percentage of total sales that are foreign sales, the ratio of foreign assets to total assets and the number of countries where a firm has subsidiaries). This measurement was employed by prior studies to investigate the relationships among international diversification, top management heterogeneous composition and firm performance (i.e. Tihanyi *et al.*, 2000).

TMT Diversity is a moderating variable in this study. Prior studies have claimed that the diversity represents the difference in values, beliefs and preferences possessed by a TMT.

The diversity reflects a higher capability to cope with complex activities and uncertainties (Hambrick and Mason, 1984). Following the definition of TMT that was widely used in the prior literature, a TMT is defined as all executives above vice president (e.g. Herrmann and Datta, 2005; Wiersema and Bantel, 1992). Previous studies have stated that the TMT diversity in terms of gender, age, functional background, educational background, tenure and nationality is relevant to the strategic decision-making process (i.e. Certo *et al.*, 2006; Nielsen, 2010). We employed the job-related attributes of TMT, educational diversity and tenure diversity, which are the most widely used in research on TMT task-related characteristics, to represent the level of TMT diversity (e.g. Carpenter, 2002; Finkelstein and Hambrick, 1996).

Educational diversity represents the level of diverse knowledge gained before the current job position. In addition, tenure diversity can represent on-job experience, which is specific to the firm (Kor, 2006). In the innovation process, we address the importance of the executive's resource management and allocation abilities; tenure can provide a more precise reflection of the managers' understanding of the company's resources. Furthermore, many prior studies have confirmed that tenure diversity is associated with the managers' knowledge and ability to guide the direction of R&D investment (Li *et al.*, 2013) and international diversification (Tihanyi *et al.*, 2000). We gained educational background information from the annual reports which stated the prior study background and the highest university degree obtained by the managers. In accordance with Wiersema and Bantel's (1992) work, we coded and separated the manager's educational background into six categories: arts, sciences, engineering, business and economics, law or other.

Educational background diversity was measured with Blau's (1977) heterogeneity index:

$$H = 1 - \sum_{i=1}^n S_i^2,$$

where H is the heterogeneity index, S_i the proportion of the TMT members in the i th educational category and n the number of different educational backgrounds (Bantel and Jackson, 1989). This indicator varies between 0 and 1, where a value close to 1 indicates a higher heterogeneity in the educational background, and a lower value reflects a uniform TMT educational background. TMT tenure was computed as the average tenure for a position in a TMT, and tenure diversity was calculated by dividing the standard deviation by the mean. Several control variables were included in this study. TMT size will affect the heterogeneity of TMTs (Tihanyi *et al.*, 2000), thus we used the total number of TMT managers to measure TMT size. The executive's international experience is associated with a firm's abilities in R&D investment and the decision-making process regarding foreign expansion (Barkema and Shvyrykov, 2007). The TMT's international experience was measured as the percentage of the executives in the TMT that had experience working or studying abroad. In addition, we controlled for the influence of firm's prior performance on innovation. Firms with poor performance had a greater willingness to pursue strategic change; therefore, we examined the return on assets (ROA) in 2007 to measure prior performance. Moreover, innovation outcome is influenced by firm size because larger firms are more likely to have a larger TMT, as well as to possess more resources and a greater ability to process complex information (Hambrick and D'Aveni, 1992). Firm size, in this study, was measured by the total assets of a firm in 2008. We also controlled for the influence of firm's international experience that is related to a firm's ability to perform international diversification. The firms with more international experience accumulate more knowledge related to the international environment and have a higher confidence to operate in foreign countries. The measurement of a firm's international experience was calculated as the time between the first year a firm set up a subsidiary in a foreign country and 2008. We adopted the natural logarithm of the firm's international experience. Firms may engage in R&D activities differently between sub-industries, and this is

especially true for firms in the semiconductor industry, which produce a greater number of patent applications than firms in other sub-sectors of the information technology industry. We used an industry dummy to control for the different sub-industries effect. The firms in the semiconductor industry were coded as 1 and those in other industries were coded as 0.

Method

Patents had integer and non-normal distribution characteristics. Poisson regression and negative binomial regression are both well-accepted models to examine discrete data, and they have been widely used in prior studies (e.g. Almeida and Phene, 2004; Stuart, 2000). We applied negative binomial regression to test the models because it provides a better model specification to correct the concern of over-dispersion in the dependent variable (Phene and Almeida, 2008; Rodriguez, 2013).

Results

Descriptive statistics results

Table I provides basic information about the 283 valid sample firms in this study, demonstrating that the average TMT of each firm consisted of 5.98 managers. In addition, the average prior ROA was 6.72 percent, the R&D investment of a firm was 4.87 percent and the average number of patent applications by a firm was 7.24. Moreover, the correlations between variables were lower than 0.5 and the low variance inflation factor, ranging from 1.06 to 1.66, suggested that multicollinearity was not a serious problem in our analysis.

Table II shows the results of the effect of R&D investment and international diversification on innovation performance, and the moderating effect of TMT diversity. All control variables are included in Model 1. Models 2–4 incorporate the effect of the main and the moderating effect, and Model 5 presents the comprehensive model. Model 2 shows that R&D investment and international diversification are positively associated with innovation performance ($\beta = 0.045$, $p < 0.05$; $\beta = 1.346$, $p < 0.05$). The results indicate that firms that invest more resources in R&D and develop more international activities tend to have a better innovation outcome.

In Model 5, the finding presents mixed results regarding the moderating effect of TMT diversity on the relationship between R&D investment and innovation performance. The results demonstrate that educational diversity does not have a significant positive impact on the relationship between R&D investment and innovation performance ($\beta = 0.101$, $p > 0.1$). The finding shows that educational diversity does not enhance the relationship between R&D investment and innovation performance. Thus, *H1a* is not supported. However, tenure diversity positively moderates the relationship between R&D investment and innovation performance ($\beta = 0.267$, $p < 0.1$). The result confirms that tenure diversity facilitates resource allocation in the R&D investment process and contributes to innovation performance. Thus, *H1b* is supported.

In addition, Model 5 demonstrates the moderating effect of TMT diversity on the relationship between international diversification and innovation performance. The result reveals that educational diversity has a significantly positive impact on the relationship between international diversification and innovation performance ($\beta = 0.259$, $p < 0.05$). The finding indicates that educational diversity reinforces the positive relationship between international diversification and innovation performance. The result supports *H2a*. However, we found an insignificant moderating effect of tenure diversity on the relationship between international diversification and innovative performance ($\beta = 0.026$, $p > 0.1$). Thus, the positive moderating effect of TMT tenure diversity proposed by *H2b* is not supported.

Table I.
Descriptive statistics
and correlations

| | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------------------------------------|--------|--------|----------|----------|--------|--------|--------|----------|------------|----------|--------|-------|
| 1. Innovation performance | 7.240 | 15.975 | 1.000 | | | | | | | | | |
| 2. TMT size | 5.982 | 3.682 | 0.266*** | 1.000 | | | | | | | | |
| 3. TMT's international experience | 0.141 | 0.139 | 0.066 | 0.147* | 1.000 | | | | | | | |
| 4. Firm's prior performance | 6.725 | 11.424 | 0.130* | 0.011 | 0.063 | 1.000 | | | | | | |
| 5. Firm size ^a | 15.062 | 1.197 | 0.337*** | 0.408*** | 0.086 | 0.063 | 1.000 | | | | | |
| 6. Firm's international experience | 2.147 | 0.585 | 0.111 | 0.079 | -0.072 | -0.060 | 0.134* | 1.000 | | | | |
| 7. Industry dummy | 0.120 | 0.326 | 0.171** | 0.034 | 0.121* | 0.082 | 0.067 | -0.130* | 1.000 | | | |
| 8. R&D investment | 0.456 | 0.203 | 0.101 | -0.053 | 0.149* | 0.002 | -0.093 | -0.147* | 0.2496*** | 1.000 | | |
| 9. International diversification | 0.539 | 0.260 | -0.005 | -0.160** | -0.057 | 0.076 | -0.058 | 0.263*** | -0.3174*** | -0.175** | 1.000 | |
| 10. Educational diversity | 4.874 | 7.718 | 0.032 | 0.207*** | 0.113 | -0.090 | 0.087 | -0.100 | -0.078 | -0.006 | -0.089 | 1.000 |
| 11. Tenure diversity | 0.487 | 0.199 | 0.093 | 0.023 | -0.016 | -0.027 | -0.014 | 0.062 | 0.043 | -0.092 | 0.046 | 0.004 |

Notes: ^aA natural logarithm of total asset. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|------------------|------------------|------------------|------------------|------------------|
| TMT size | 0.135**** (0.06) | 0.135**** (0.05) | 0.132**** (0.05) | 0.137* (0.05) | 0.134* (0.05) |
| TMT's international experience | 0.096 (0.87) | 0.336 (0.91) | 0.073 (0.94) | 0.175 (0.92) | -0.026 (0.93) |
| Firm's prior performance | 0.038** (0.01) | 0.034* (0.01) | 0.034* (0.01) | 0.034* (0.01) | 0.033* (0.01) |
| Firm size | 0.000**** (0.00) | 0.000* (0.00) | 0.000* (0.00) | 0.000**** (0.00) | 0.000**** (0.00) |
| Firm's international experience | 0.223 (0.21) | 0.231 (0.21) | 0.155 (0.22) | 0.286 (0.22) | 0.243 (0.23) |
| Industry dummy | 0.679* (0.37) | 0.565**** (0.44) | 0.511 (0.42) | 0.612**** (0.44) | 0.635**** (0.43) |
| R&D investment | | 0.045* (0.02) | 0.060**** (0.03) | 0.041**** (0.02) | 0.051* (0.03) |
| International diversification | | 1.346* (0.70) | 1.441* (0.70) | 1.133* (0.68) | 1.183* (0.69) |
| Educational diversity | | -0.212 (0.64) | -0.158 (0.65) | -0.237 (0.63) | -0.128 (0.63) |
| Tenure diversity | | 1.037* (0.49) | 1.045* (0.49) | 1.005* (0.49) | 1.005* (0.49) |
| R&D investment × Educational diversity | | | -0.027 (0.20) | | 0.101 (0.20) |
| R&D investment × Tenure diversity | | | 0.284**** (0.19) | | 0.267**** (0.19) |
| International diversification × Educational diversity | | | | 0.253* (0.12) | 0.259* (0.13) |
| International diversification × Tenure diversity | | | | 0.001 (0.12) | 0.026 (0.12) |
| cons | -0.114 (0.57) | -1.574* (0.71) | -1.492* (0.71) | -1.519* (0.74) | -1.491* (0.74) |
| Likelihood ratio χ^2 | 40.83*** | 53.67*** | 55.94*** | 57.56*** | 59.54*** |
| Pseudo R^2 | 0.029 | 0.038 | 0.039 | 0.041 | 0.042 |

Notes: The report coefficients are exponentiated betas. Standard errors are reported in parentheses. One-tailed tests for hypothesized effect. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.1$

Table II. Negative binomial regression results: the moderating effect of TMT diversity on the relationship between R&D investment, international diversification and innovation performance

Discussion

Our findings are consistent with prior studies which pointed out that the TMT's diversity plays a role in prompting innovation (Ndofor *et al.*, 2015; Yoshida *et al.*, 2014). When firms invest in R&D, the diverse tenure TMTs incorporate the external opportunities and the organization's internal resources to successfully exploit innovation sources to yield innovative outcomes. The greater diversity of tenure has the broader experience required to connect with the external environment and is able to distribute internal resources efficiently, leading to a better innovation performance (Heyden *et al.*, 2013). Such a diversity enhances the managers' ability to create and provide novel strategic innovation, and this finding is consistent with Alexiev *et al.*'s (2010) study. The result also supports the resource-based view, which proposed that the managerial services and knowledge provided by the top managers allow them to cope with the complex activities that affect the firms' resource management and innovation (Heyden *et al.*, 2013).

However, the TMT diverse tenure experience is highly specific to a team. Firms may be better able to develop other types of expertise, such as cross-industry knowledge, combined with tenure experience to cope with the complex information in the process of R&D investment. Thus, our finding was supported at the 10 percent level, which offers an admittedly limited degree of confirmative evidence. In particular, the complexities and uncertainties are more challenging in the international market. Other types of knowledge are required in order to efficiently sift through complex market information and opportunities from foreign markets. Thus, tenure diversity facilitates the relationship

between R&D investment and innovation performance but does not ensure a relationship between international diversification and innovation performance.

As regards the relationship between internationalization and innovation performance, our findings indicate that the managers' diverse education background is relevant when processing complex information during the internationalization process (Tihanyi and Thomas, 2005). This finding confirmed the argument raised by upper echelons theory that the top managers' diverse backgrounds largely affect the managers' decision-making process and a firm's successful innovation (Bantel and Jackson, 1989; Hambrick and Mason, 1984).

A heterogeneous study experience creates a diverse problem-solving ability in the decision-making process when firms carry out internationalization (Ndofor *et al.*, 2015). In addition, this heterogeneous educational training enhances the executives' ability to cope with the uncertainty caused by the dynamic environment of the international market, and the result of our research is consistent with Carpenter and Fredrickson's (2001) argument that educational diversity contributes to the company's increased global position. Furthermore, a benefit of a diverse educational background is that it brings a broader network, which enhances the company's ability to evaluate information when entering the international market, confirming Barkema and Shvyrkov's (2007) claim that educational heterogeneity among the TMT leads to more creative responses to the diverse demands of the international market.

On the other hand, the finding of the positive effect of educational diversity enhances the relationship between international diversification and innovation performance. The educational diversity of the executive team brings the advantage of a wider base of knowledge to evaluate R&D activities, but the diverse knowledge accumulated from prior educational experience is less specific to a particular company. Therefore, educational diversity can enhance the relationship between international diversification and innovation performance but does not have a significantly positive impact on the relationship between R&D investment and innovation performance.

Conclusion

The findings of this research contribute to the literature in several areas. We extend the research of prior studies regarding the direct relationships between R&D investment, international diversification and innovation performance (i.e. Kafouros *et al.*, 2008; Love and Mansury, 2007). We apply upper echelons theory to explain the role that TMT educational diversity plays in the creation of a more favorable innovative performance. In addition, the resource-based view provides a theoretical base for this study's explanation of how tenure diversity affects the resource allocation, and drives increased innovation performance. Furthermore, we contribute to the categorization of different types of TMT diversity, in terms of educational diversity and tenure diversity, to give a better understanding of how TMT diversity affects the management of the innovation process and enhances innovation performance.

This study has several limitations. First, we investigated cross-sectional data covering the period 2008–2009, which was when the global financial crisis occurred; therefore, the innovation performance may be lower than average because firms were subjected to reduced financial and leverage capability. We suggest that future studies should apply a longitudinal design to provide a better explanation for the casual relationship of R&D investment on innovation performance. In addition, certain innovative inputs may require a longer period of time to generate innovation performance. Thus, future studies can apply longer longitudinal data to investigate the time lag effect. Other TMT experience and knowledge background, such as diversity in gender, functional experience, industry experience and international background, that influence multiple levels of the team's

effectiveness, can also be included in order to investigate the association with innovation performance in future research (e.g. Nielsen and Hillman, 2018).

In consideration of the effect of R&D investment and international diversification on innovation performance, future studies could identify other moderating or mediating variables. Given the possibility of communication obstacles and conflicts caused by TMT diversity, future studies could jointly investigate subgroup characteristics, such as the fault lines and the interface between the CEO and the TMT, to determine whether interpersonal interactions increase communication costs and benefit innovative decision making (e.g. Georgakakis *et al.*, 2017; Ndofor *et al.*, 2015; Nielsen and Hillman, 2018). Innovation performance can be demonstrated by other outcomes, such as new product introduction, product market entry or international patent announcement. Industry growth and environment uncertainty affect TMT managerial discretion in R&D investment and international diversification; therefore, future studies could apply other types of measurement of innovative performance, including the uncertainty factor, to deepen the understanding of the influence of the TMT decision-making process on innovation.

Moreover, including other organizational factors, such as communication mechanisms and cultural structures, within organizations, and connecting relationships with external organizations, will ensure a more accurate clarification of the relationships between innovation sources and innovation performance. For example, innovation performance may decrease with a declining learning effect due to reduced international expansion. How TMTs exploit knowledge sharing and develop an integration mechanism to supplement this declining learning effect could be further addressed in future studies. In addition, although this study included TMT diversity as an important moderating variable, our research did not examine the black box of TMT processes such as interaction among members of TMT. As a result, we recommend the inclusion of the interaction process of TMT in further studies to contribute to upper echelons research.

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Further reading

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