STUDIES ON FEMALE FORCE PARTICIPATION IN TMT AND TECHNOLOGICAL INNOVATION CAPABILITY

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ABSTRACT

Technological innovation capability is playing an increasingly important role to maintain the competitive advantages for SMEs (small and medium enterprises) in China. Meanwhile, more and more Chinese women are getting out of the family and going to work. Some of them even become top executives of firms. In this context, the analysis of the impact of female force participation in TMT (top management team) on firms’ technological innovation capability in this paper becomes very necessary and important. If female executives can indeed promote firms’ technological innovation capability through a unique way, firms should attract more suitable female executives to join TMT and should implement appropriate strategies to make the best use of their value. This paper separates female participation in TMT into two categories: ordinary female executives and female CEOs. Firstly, the overall effect of female participation in TMT on firms’ technological innovation capability is examined. Secondly, R&D intensity variable is introduced to see whether female participation in TMT and firms’ R&D-intensive strategy has a synergy effect on firms’ technological innovation capability or not. In addition, competition intensity variable is introduced to test the impact of female executives on firms’ technological innovation capability when faced with fierce competition. Finally, the co-effects of female participation in TMT and various innovation methods are also discussed.

Keywords: female participation in TMT, technological innovation capability, gender differences, organizational learning capability, competition
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CHAPTER 1
INTRODUCTION

Research Background

With the acceleration of globalization and the deepening of reform and opening up of Chinese economy, Chinese market is integrated gradually into the global market. In addition, Chinese government is now deepening the reform of economy in an all-around way, which emphasizes the decisive role of market power. All these make a further demand to the enterprise management of Chinese firms. When faced with increasing competition, Chinese firms should constantly enhance their competitive advantages. One of the most important sources of competitive advantages is technological advantage, and the realization of technological advantage is based on strong technological innovation capability. Hence, nowadays, if firms merely depend on resource advantage, capital advantage, and trade advantage, they can’t have sustainable development. Only technological innovation is the fundamental way for firms to maintain sustainable competitiveness in long-term.

Mone et al. (1998) and Cho et al. (2005) both asserted that technological innovation capability is one of the key determinants of firm performance. Technological innovation capability can provide firms with competitive advantage, and then increase the firms’ revenue and profit (Bayus et al., 2003). In addition, the positive impact of technological innovation on firm performance has been verified in different countries’ markets and has become a mainstream view. Deshpande et al. (1993) pointed out that technological innovation capability of Japanese listed companies is positively correlated
with firm performance. Hult et al. (2004) studied the American manufacturing enterprises and found out that technological innovation capability is positively related to firms’ profit growth and market share growth. Ozcelik et al. (2004) declared that technological innovation of Turkey manufacturing firms has significantly enhanced firms’ competitive power. Similarly, through the research of Canadian manufacturing enterprises, Thornhill (2006) found out that the higher the level of technological innovation, the faster the firms’ revenue will grow. Therefore, analyzing the factors that will influence firms’ technological innovation capability is becoming the focus of Chinese firms’ development strategies.

At the same time, with the progress of society, the social status of women gradually increased. Women are getting rid of the overcharge from family as a mother and a wife. Their social participation is increasing and they are making more and more contributions in some traditional male-dominated working positions. Though some invisible difficulties for women still exist in workplace (the glass ceiling), though scholars have not yet reached a consensus that female participation in TMT can promote firm performance (Adler, 2001; Carter et al., 2003; Dezso et al., 2008), the phenomenon that more and more women are working in TMT of firms in itself is important enough to draw the attention of society. There are some female leaders in world’s top 500 companies. CEO of HP, Meg Whitman, is a female. CEO of IBM, Virginia M. Rometty, is a female. CEO of PepsiCo, Indra Nooyi, is a female. CEO of DuPont, Ellen, is a female. In addition, CEO of Avon, Sheri McCoy, is also a female. In March 2014, Warren Buffett, made the following statement: the more involvement of female
determines the bright future of America. If the potential of female is released, the future development of the US will be unlimited.

In China, the change of female’s social status is bigger. In the past feudal society, Chinese women’s priority is to take care of the family rather than go out to work. Men mainly assume the work function. It is hardly to find successful women in economic or commercial activities. However, after the establishment of new China, especially after the reform and opening of Chinese economy, with the fast development of China’s private economy, more and more Chinese women are going to work and beginning to pursue their own career goals. Many female managers own or operate many good enterprises. For example, the US Fortune magazine issued “the world’s 50 most influential women in business” list in 2014. The candidates are evaluated by some indicators, such as firm’s size, firm’s position in global economy, and stability of the business, individual career path, and social influence. This list includes two Chinese female leaders. They are Dong Mingzhu, the chairman and president of Gree Electric; and Zhang Xin, the CEO of Soho China. It can be seen that Chinese female entrepreneurs and executives are rising rapidly and are creating a larger number of commercial miracles, which is not inferior to male manager’s achievements (Ren and Wang, 2011).

Therefore, as technological innovation is becoming more and more important for firms’ development and as female executives are becoming more and more influential, this paper’s analysis of the relationship between female participation in TMT and firms’ technological innovation capability is obviously necessary and important. Effective authentication and development of management skills are very crucial for firms to enhance their competitive advantages (Hambrick et al., 1984; Barney, 1991; Castanias et
al., 1991; Lado et al., 1994). Then, if female executives can truly influence firms’
technological innovation capability through their unique ways, firms should be inclined
to absorb more suitable women into TMT and design appropriate management system to
make the best use of female executives, for the purpose to maintain competitive power in
long-term. This is the meaning of this paper.

At present, most of the existing foreign and domestic studies focus on the
relationship between characteristics of TMT members and firm performance. The
characteristics of TMT members firstly influence the decision-making process and
strategic choices of managers, and then further affect firms’ growth and productivity
(Murray, 1989; Wiersema and Bantel, 1992; Pitcher and Smith, 2001). In contrast,
researches, which focus on the relationship between characteristics of TMT members and
firms’ technological innovation capability, are scarce. These researches mainly use age,
education background, working experience to describe TMT members’ characteristics
(Bantel and Jackson, 1989; Zajac et al., 1991; van der Vegt and Janssen, 2003). The
existing studies related to TMT members’ gender characteristic mainly analyze the
impact of female participation in TMT on the decision making and implementing process
of technological innovation. Up to now, foreign and domestic scholars have found out
that female executives can influence firms’ technological innovation capability by
different leadership style, different risk preference, different communication skill and
different role expectation (Eagly and Johnson, 1990; Hooijberg and DiTomaso, 1996;
Martin, 2001; Millward and Freeman, 2002; Stelter, 2002). However, a direct analysis of
female executives’ impact on technological innovation output is still a blank. This paper
hopes to address this research gap and makes own research contributions.
Research Methods

This article uses the data collected by World Bank through a survey about 2848 Chinese firms in 2012. This survey collected the information of target firms in 2011 from various aspects: relationship between government and firms, competition, security, infrastructure, funding source, corporate governance and technological innovation. At last, 448 manufacturing SMEs are reserved as research sample and STATA 12.0 is used as the data-processing software. This paper investigates the relationship between female participation in TMT and firms’ technological innovation capability, using multiple OLS regression models. Notably, this paper separates female participation into two categories: female CEOs and ordinary female executives, and discuss their different influences on firms’ technological innovation capability.

The analytical framework of this paper is as follows. Firstly, the overall effect of female participation in TMT on firms’ technological innovation capability is examined. Secondly, R&D intensity variable is introduced to see whether female participation in TMT and firms’ R&D-intensive strategy has a synergy effect on firms’ technological innovation capability or not. In addition, competition intensity variable is introduced to test the impact of female executives on firms’ technological innovation capability when faced with fierce competition. Finally, the co-effects of female participation in TMT and various innovation methods are also discussed.

This paper is structured as follows. The second part, literature review will introduce the theoretical background from four aspects: firms’ technological innovation capability, gender differences, organizational learning capability and competition intensity. Moreover, in this part, the direct studies about female participation in TMT and
technological innovation are summarized. The third part will give eight hypotheses based on solid theory. Data, variables, models and empirical results are provided in part four. And at last, the fifth part will introduce conclusions, implications and limitations of this paper.
CHAPTER 2
LITERATURE REVIEW

Firms’ Technological Innovation Capability

Types of Innovation

With regard to firms, innovation means to adopt a new idea or a new behavior, including new product, new service, new production process, new institution and new project (Aiken and Hage, 1971; Daft, 1982; Damanpour and Evan, 1984). There are various types of innovation and there are also many classification methods. To sum up, two main classification methods exist, according to the innovation object and the radicalness of innovation.

According to the innovation object, innovation can be divided into technological innovation and administrative innovation. Technological innovation is directly related to firms’ daily operation, includes product innovation, service innovation and production process innovation (Knight, 1967; Damanpour and Evan, 1984). Among them, product innovation refers to develop or introduce a completely new or improved product, and finally make it successful in market. The main purpose of product innovation is to enhance the profitability of firms by differentiating the products and increasing the sale price. Production process innovation refers to improve or change the manufacturing methods, manufacturing tools and distribution ways of products. The main purpose of production process innovation is to increase firms’ profitability by decreasing the production cost. Service innovation refers to introduce new technology into existing service and then to introduce this new service into market (Boone, 2000). In contrast with
technological innovation, administrative innovation is not directly related with firms’
daily operation, but directly related with firms’ management. Administrative innovation
mainly includes organizational structure innovation and management process innovation
(Evan, 1966; Knight, 1967; Damanpour and Evan, 1984). This paper focuses on the
technological innovation of firms.

According to the radicalness of innovation, innovation can be divided into two
categories: radical innovation and incremental innovation. For example, Knight (1967)
distinguished with “routine” innovation and “non-routine” innovation. The former
implies a minor change to existing product, service or production process. The latter
implies to introduce changes to the internal and external environment of innovation
subject. In addition, Grossman (1970) raised the concept of “instrumental” innovation
and “ultimate” innovation. The former refers to the innovation, which is adopted in the
early stage to facilitate the success of ultimate innovation. The latter means the
innovation that ends in itself. Ultimate innovation is the final stage of a series of
innovation activities. Similarly, Normann (1971) used the term “variation” and
“reorientation” in his research. The former one implies improvement and refinement to
existing products. The latter, however, implies a fundamental change to existing ones.
Though scholars use different terms, their meanings are the same. Routine, instrumental
and variation innovations are incremental innovations, which have a lesser difference
with existing products, service or production process. In contrast, non-routine, ultimate
and reorientation innovations are all radical innovations, which have obvious differences
with existing product, service or production process (Dewar and Dutton, 1986; Ettlie et
al., 1984).
Determinants of Firms’ Technological Innovation Capabilities

There are many factors that affect the capability of technological innovation. Damanpour (1991) and Wolfe (1994) divided them into three categories: characteristics of firm members, characteristics of firm itself and environmental factors.

Characteristics of firm members: Based on the theory of entrepreneurship, characteristics of firm executives are important determinants of firms’ technological innovation capability (Amit et al., 1993). Managers not only recognize the innovation opportunities and coordinate the usage of various resources (Fontes and Coombs, 1996), but also use their own management competencies to guide other employees to work and establish contacts with external organizations for the benefits of innovation (Lipparini and Sobrero, 1994). The characteristics of firm executives generally include age, gender, education background and amount of relevant work experience (Avlonitis et al., 1994). The attitudes of managers towards innovation and their responding actions will also be influenced by their personal characteristics (Rizzoni, 1991). In this paper, gender characteristic is chosen to discuss.

Characteristics of firm itself: Resource-based theory emphasizes the importance of characteristics of firm itself for enterprises to enhance their technological innovation capability (Barney, 1991). R&D input and technical employees are two fundamental factors, because they respectively describe firms’ knowledge intensity and organizational learning capability (Koschatzky and Zenker, 1999). In addition, common characteristics of firm itself also include: percentage of highly educated employees (Meeus et al., 2001), technology scanning ability, written strategic plan (Avlonitis et al., 1994; Keogh and Evans, 1999), internationalism (Fontes and Coombs, 1997), organizational structure
(centralization, formalization et al.), firm size and firm age. In this paper, percentage of technical staff, education level of employees, firm size and firm age are altogether used as controlled variables.

Environmental factors: For the purpose of filling the blank of resource-based theory, for the purpose of emphasizing the important influence of societal and macro-economic factors on firms’ technological innovation capability, environmental factors are taken into account. Just because of the consideration of such external factors, Porter (1980) included “Structure, Conduct, Performance” paradigm into his five-force model. Moreover, technological innovation is an interactive process. Hence, the influence of the linkage between firms and the external environment should be considered favorably (Rothwell, 1991). This interactive network not only includes the pure economic relationship between firms and firms, but also includes the interaction and mutual learning in societal and cultural level (Amit et al., 1993). The common environmental determinants include: intensity of competition (Birchall et al., 1996), hostility of environment (Kim et al., 1993), uncertainty and dynamism of environment (Damanpour, 1996), intensity of the interactive network (Decarolis and Deeds, 1999), external technical connection (Rothwell and Dodgson, 1991) and external innovation barriers (Keogh and Evans, 1999). In this paper, competition is included in the model to build interaction terms.

To sum up, Table 1 presents the three kinds of determinants that can influence firms’ technological innovation capability.
Table 1.
Determinants of Firms’ Technological Innovation Capability

<table>
<thead>
<tr>
<th>Characteristics of firm members</th>
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<td></td>
<td>Gender</td>
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<td>Education level</td>
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<td>Working experience</td>
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<td>Insight</td>
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<td>Firm size</td>
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<td></td>
<td>Firm age</td>
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<tr>
<td></td>
<td>Sales</td>
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<td></td>
<td>Internationalism</td>
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<td></td>
<td>Written strategic plan</td>
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<td></td>
<td>Technology scanning capability</td>
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<tr>
<td></td>
<td>R&amp;D expenditure</td>
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<tr>
<td></td>
<td>Technical employees</td>
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<td></td>
<td>Highly educated employees</td>
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<td></td>
<td>Organizational structure</td>
</tr>
<tr>
<td>Characteristics of firm itself</td>
<td>Competition intensity</td>
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<tr>
<td></td>
<td>Environment hostility</td>
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<td>Environment uncertainty and</td>
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<td>Network intensity</td>
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<td></td>
<td>External technical connection</td>
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<td>External innovation barriers</td>
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More intuitively, Figure 1 presents the classic “antecedents” model of innovation developed by King (1990). In addition to the three kinds of factors discussed above, King (1990) highlighted the national innovation policies (NIP) and inter-firm linkages. Though these two factors belong to environmental factors, they are listed here separately due to their particular importance. It should be noted that this model only presents the most direct and simple relationship between the antecedents and firms’ technological innovation capability. In fact, firms’ technological innovation capability may have a reverse impact on these antecedents, and there may be interaction between different factors.
There exist a large number of determinants that can influence firms’ technological innovation capability. So it is impossible to do an empirical analysis for all of them in one paper. This article focuses on the gender characteristic of firm members. Other factors will be included in future studies to get a more comprehensive understanding about how to foster firms’ technological innovation capability.

**Figure 1.** The “antecedents” model of innovation. (King, 1990)

**Technology Innovation Methods**

Suitable innovation method is crucial for firms to increase technological innovation capability. There are various technological innovation methods. This paper divides them into two categories based on different innovation subjects: internal independent innovation and external cooperative innovation. Moreover, external cooperative innovation can further be divided into four kinds: cooperation with suppliers, cooperation with clients, cooperation with research institutions and direct copy of existing products.

Internal independent innovation means that firms only use internal resources and self-owned technologies to innovate and obtain benefits. Internal independent innovation
usually comes from the knowledge creation of an individual employee (Simon, 1991), and then the innovative idea will be shared by a group of employees with similar knowledge structure and form a practice community (Brown and Duguid, 1991). Finally, this innovative idea will be combined with firms’ existing knowledge and be used in the production process of new product or service. With the help of internal independent innovation, firms can accumulate production experience earlier than competitors and set restrictions to followers by developing industry technical standards. However, internal dependent innovation also has disadvantages. It requires a lot of capital investment and a high technical skill level. The firms also need to bear the risk of innovation failure alone. In general, the efficiency of internal independent innovation is mainly affected by competitive environment, organizational culture, organizational structure and firms’ technical level (Starbuck, 1992; Fiol and Lyles, 1985).

External cooperative innovation means firms’ joint innovation behaviors with external organizations. This kind of innovation is based on its pooling-of-interest feature. The firms share resources and information with external organizations to reduce the uncertainty of technological innovation. There are various kinds of external cooperative innovation: firstly, in many industries, the feedbacks from client, especially from the lead users, are important source of technological innovation (Pascale, 1984). Secondly, cooperation with suppliers can effectively decrease the input cost or enhance the quality of raw materials. Thirdly, many innovations come from direct copy of existing products in market. A lot of enterprises have professional competitor analytical system to monitor other firms’ patents (Ghoshal and Westney, 1991; Bierly and Chakrabarti, 1996a). Fourthly, many firms absorb new ideas from research institutions. By integrating both
sides’ professional knowledge, leverage effect will be generated. This can effectively increase firms’ competitive power (Teece, 1992; Quinn and Hilmer, 1995; Mowery et al., 1996). With its pooling-of-interest, risk sharing and complementary-advantage feature, external cooperative innovation is welcomed in many firms. However, it also has a higher demand for enterprises’ organizational learning capability. Because different firms have different reference framework, different technical standards, different languages and rules, it is very difficult for firms to truly understand and integrate the external information (Bierly and Chakrabarti, 1996b).

In fact, with regard to the choice of innovation methods, there is no absolute good or bad choice. The key is to choose the most appropriate innovation method for a specific firm. When choosing innovation methods, companies should consider their technical capability, customer needs, market development, and intensity of competition, patent protection efforts and so on. In addition, the characteristics of firm members should also be considered. Hence, this paper will discuss the co-effects of female participation in TMT and different technological innovation methods.

**Gender Differences**

Gender Differences in modern corporate governance are increasingly causing foreign and domestic scholars’ attention. Female executives and male executives are systematically different in aspects of values, leadership styles, management skills and behaviors. Female participation in TMT can overcome some disadvantages of a TMT, which is composed entirely of men, such as lack of vision and internal communication. In recent years, more and more researches focus on female participation in TMT, and most of them focus on gender differences. The studies found out that female generally are less
confident and more risk-averse. Therefore, firms’ technological innovation capability is also likely to be affected by female executives’ personal traits.

**Non-overconfidence**

In the field of behavioral finance, overconfidence implies that the behavior subjects overly trust their own judge abilities and tend to underestimate investment risks or overestimate investment gains in the investment decision-making process. Similarly, in the field of psychology, overconfidence implies that when behavior subjects compare their own abilities with others, they tend to believe that their abilities are above average. The existence of such "better than average" thought can influence the attribution bias of behavior subjects. As a result, behavior subjects tend to attribute the success to their above-average capability, and tend to blame other objective reasons for the bad results.

Currently, the researches of both psychology and behavioral finance stated that male is more overconfident than female (Lundeberg, 1994; Bengtsson, 2005). Hence, gender becomes a suitable index to measure overconfidence of top managers. Peng and Wei (2007) compared 121 female top managers (CEO and chairman) of S&P 1500 firms with the male top managers, in order to investigate the impact of gender differences on investment decision-making. The results showed that the overinvestment of female executives is significantly less than that of male executives. The cash flow sensitivity of female executives’ investment cost and M&A activities is also significantly lower than that of male executive. Peng and Wei (2007) believed that this situation is a result of the non-overconfident trait of female. Similarly, Tan and Wang (2006) also pointed out that the overtrading of Chinese female investors is less than the overtrading of Chinese male investors.
Risk Aversion

Earlier studies have found out that female is more risk-averse than male. The percentage of high-risk assets in female-controlled investment portfolios is normally lower than the percentage of high-risk assets in male-controlled investment portfolios (Bernasek and Shwiff, 2001; Agnew et al., 2003). Moreover, the risk-aversion trait of female is also testified in simulated game experiments and risk-preference questionnaires (Levin et al., 1989; Prince, 1993; Barsky et al., 1997).

In the field of behavioral finance, many scholars studied the risk-aversion characteristic of female. Stinerock (1991) declared that female is more risk-averse. Female feels more nervous when making financial decisions and is more willing to consult a financial adviser. Powell and Ansic (1997), Barber and Odean (2001) all believed that gender differences directly cause the difference of investment judgment. In the same decision-making context, female will adopt a more conservative investment strategy than male, showing the intention of risk-aversion. Watson and Mcnaughton (2007) studied the investment style of individual pension of Australian universities and pointed out that female investors’ investment portfolios are more conservative. Notably, Atkinson (2003) stated that there is no actual differences between male and female fund managers’ investment behaviors, risk control and investment performance. However, the choices of investors are significantly affected by the gender of fund managers. Investors are more willing to let male fund managers take care of their assets. In addition, Ryan (2005) also pointed out that when faced with risk and difficulties, the board is more willing to appoint female top managers to reduce risk.
Scholars provide three main explanations for the risk-aversion characteristic of female. The first explanation is the societal and cultural difference. Slovic (1996) believed that the societal expectation for female is less than the societal expectation for male. Therefore, female is thought to be not necessary to take excessive risks. The second explanation is physical difference. Laborde (1994) pointed out that women’s reproductive responsibilities make them more risk-averse. Hersch (1996) also believed that because women on average live longer, so women who take excessive risks may suffer a greater loss. Hence, female’s decision will be more careful and conservative. The third explanation is information processing difference. Male investor will not take all the information available into consideration. However, they will selectively use the information that is consistent with their past experiences. On the other hand, female is good at analyzing comprehensive information. So, female can give better evaluation of potential risks (Graham, 2002).

Then, whether female executives also have the non-overconfidence and risk-aversion traits or not, and how can these traits influence firms’ technological innovation capability; these are the issues this paper wants to investigate.

**Organizational Learning Capability**

Though many SMEs have gradually recognized the importance of technological innovation, they do not have enough internal resources to innovate successfully. They can’t make adequate human capital and physical capital investment. Hence, only the firms that can successfully connect limited internal resources with abundant external resources will maintain competitive advantages. The organizational learning capability is just the key for firms to make the connection (Cahill, 1997). Through organizational
learning, the relationship between SMEs and their clients will become wider and more flexible, stimulating the firms’ growth (Cahill, 1997).

Wyer and Mason (1999) defined organizational learning as a strategic learning process that occurs within SMEs which can effectively maintain the development of firms, and as a management method that can respond to various unpredictable changes by giving rights to key individuals within firms. Saban et al. (2000) also believed that organizational learning capability can help firms to consistently obtain and process new information, to increase knowledge reserve and enhance the decision-making quality. To sum up, organizational learning capability can help firms developing internal and intra-firm communication and processing information to confront various unpredictable changes and promote technological innovation capability.

Within an organization, the increase of dialogue will cause synergy (Isaacs, 1993). Hence, dialogue within the organization can enhance organizational learning capability, allowing firms to understand more complex information (Stacey, 1996; Romme and Witteloostuijn, 1999; Cook, 1999). Take the impact of gender differences into consideration, current studies believe that the empathy of female is stronger than male. Female can feel other people’s emotion more accurately and female have better communication skills. Therefore, female executives may have more significant promotion to organizational learning capability than male executives (Claes, 1999). As a result, female managers’ cooperative style, empathy, and communication skills are becoming more and more important for administrative management, while male executives are more likely to be described as inflexible (Claes, 1999).
In a word, female participation in TMT can stimulate firms’ organizational learning capability, and then improved organizational learning capability can further promote firms’ technological innovation capability. Generally, a R&D-intensive enterprise needs to digest more information than a non-R&D-intensive enterprise. Naturally, R&D-intensive firms need a higher-level organizational learning capability. Thus, this paper will investigate the impact of female participation in TMT on R&D-intensive firms’ technological innovation capability. This can verify whether female executives can promote organizational learning capability or not.

**Competition Intensity**

Although scholars have always been trying to understand the relationship between competition intensity and technological innovation, this topic is still not conclusive.

Some scholars believe that monopoly power is an important prerequisite for technological innovation, thus competition intensity is negatively related to firms’ technological innovation capacity. These scholars based their researches on the classic assumptions developed by Schumpeter: market power offers firms the guarantee for benefits from technological innovation. In other words, industry concentration is positively related to firms’ technological innovation capability. Similarly, industrial organization theory also suggests that technological innovation decreases as competition intensity increases, because competition reduces the rewards for innovator. For example, Gilbert (2006) declared that though competition stimulates more enterprises to invest more in R&D activities, firms have no motivations to innovate if there is no enough patent protection, because they can’t enjoy the profits alone.
However, other scholars believe that the competition pressure is the key to make companies invest more in R&D activities, thus competition intensity is positively related to firms’ technological innovation capability. For example, Nickell(1996), Blundell et al. (1999) all found out that there exists a significant relationship between the competition intensity and firms’ innovation output. Schmidt (1997) even stated that though patent protection is not good enough, competition could still encourage managers to increase R&D expenditure, for the purpose of avoiding bankruptcy.

In addition, different from the above discussion, Aghion(2005) pointed out that there is an inverted-U shape relationship between competition intensity and firms’ technological innovation capability, which means that there is optimal competition intensity for firms. When competition intensity is too low, firms can’t find motivations to innovate. When competition intensity is too high, the instable market environment is not suitable for firms to innovate, either. Hadjimanolis (2000) did a research about SMEs in Cyprus and found out that competition intensity does not really influence firms’ technological innovation capability. When faced with fierce competition, the SMEs in Cyprus are more likely to cut cost or strengthen marketing efforts, instead of implementing innovation.

To sum up, the relationship between competition intensity and firms’ technological innovation capability is inconclusive. Different countries have different economic features. Chinese economy is in the transition period, and the typical feature of transition period is the lack of a complete legal framework to define intellectual property rights (Choi, Lee and Kim, 1999; Hoskisson et al., 2000; Li and Atuahene, 2002). The protection for patent is not enough. Additionally, Chinese government decided to let the
market play a decisive role. Hence, the market competition will become more and more intense. In this background, SMEs in China will not only face the risk of innovation failure, but also will face the risk of losing profit after the innovation success. Therefore, the overall risk for Chinese SMEs to innovate is quite high. In this paper, the impact of female participation in TMT on firms’ technological innovation capability will be investigated in a fierce competition environment.

**Direct Studies about Female Participation in TMT and Firms’ Technological Innovation Capability**

The discussion above summarized the types of technological innovation, determinants, methods and gender differences. Now, the direct studies about the female participation in TMT and technological innovation are as follows.

Some scholars believe that gender characteristic of executives indeed influences firms’ technological innovation capability through risk preference, communication skill, role expectation and leadership style. Eagly and Johnson (1990), Hooijberg and DiTomaso (1996) pointed out that male executives are less risk-averse, thus are more willing to adopt an innovation project and invest resources in it. In contrast, female executives are good at building intimate relationship with employees because of their more participative leadership style, thus they may have more positive impact on the implementation process of innovation project. Martin (2001) found out that female executives can promote the internal communication of firms, and enhance firms’ organizational learning capability. These features are beneficial to innovation. Millward and Freeman (2002) stated that male executives are more likely to adopt radical innovation and female executives are more likely to adopt incremental innovation,
because of their different role expectation. In addition, Stelter(2002) declared that female executives’ leadership style is more revolutionary, thus female executives are willing to adopt more innovation projects.

In contrast, some scholars believe that gender differences of top managers do not significantly influence firms’ technological innovation capability. Sonfield (2001) pointed out that male and female executives do not have different preference when make innovation decisions. Damanpour and Schneider (2006) also found out that managers’ gender does not have significant impact on the adoption and implementation process of technological innovation.

Notably, the direct empirical analysis of the relationship between female participation in TMT and firms’ technological innovation output is very scarce. It is almost an uncovered research field. Only Zeng (2012) used percentage of R&D expenditure on sales as a measure of technological innovation input to study the firms on GEM in China from 2009 to 2010. Zeng (2012) stated that female participation can significantly promote firms’ technological innovation capability and human capital can strengthen this relationship. Additionally, the research found out that industry plays a moderating role: the promotion effect of female participation in TMT is more obvious in high-tech and telecom industries.

To sum up, researches have shown that female executives can influence firms’ technological innovation capability by different leadership style, different risk preference, different communication skill and different role expectation. However, a direct analysis of female executives’ impact on technological innovation output is still a blank. This paper hopes to address this research gap and make its own research contributions.
CHAPTER 3
THEORY AND HYPOTHESES

According to the literature review, gender characteristic as one of the TMT member factors, can influence firms’ technological innovation capability and should be considered when firms choose innovation methods. Compared to male, female is risk-averse, approachable, good at communication and less confident. Hence, when a R&D intensive strategy is adopted and when faced with fierce competition, female executives are likely to impose unique impact on firms’ technological innovation capability. Before the empirical analysis, eight hypotheses are proposed.

Compared to male executives, female executives have more revolutionary leadership style, and are more likely to adopt innovation activities (Stelter, 2002). The leadership style of female managers is also more participative, thus female executives are good at establishing intimate relationship with employees (Eagly and Johnson, 1990; Hooijberg and DiTomaso, 1996). Moreover, female executives’ communication skills are better, which can stimulate the organizational learning capability and promote technology innovation (Martin, 2001).

Moreover, in the daily operation, top managers have to deal with a large amount of information and must promptly respond to the information, to keep important information and discard useless information (Mintzberg, 1973). The reactions of top managers depend on their interpretation of the information. Normally, their interpretation will be based on their own habits or behavioral norms, such as religious beliefs, values, work experience, knowledge reserve and so on (Finkelstein and Hambrick, 1990). Then, when TMTs have strong heterogeneity, the strategic choices of firms will be depend on the various values and behavioral methods of top managers, thus the strategic choices
will focus more on innovation (Talke et al., 2010). The heterogeneity of TMTs can help firms become industry leaders, not followers. It means that they will introduce new products or services earlier than their competitors (Srivastava and Lee, 2005). It is obvious that female participation increase the heterogeneity of TMT. On one hand, TMTs with female executives can make good use of the respective advantages of male and female. The empathy, detail-orientation and sensitivity of female executives can provide firms with different point of views and different methods to solve problems. On the other hand, female participation can help firms better understand the clients’ needs, especially the female clients’ needs. Then, firms can produce differentiated products to win competitive advantages (Carter et al., 2003; Carter et al., 2010).

Based on the above claims, hypothesis 1 and hypothesis 2 are given.

Hypothesis 1: Generally, ordinary female executives promote firms’ technological innovation capability.

Hypothesis 2: Generally, female CEOs promote firms’ technological innovation capability.

Organizational learning capability is crucial for firms to connect internal and external resources. Only the firms with strong organizational learning capability can obtain competitive advantages in technological innovation (Cahill, 1997). Organizational learning capability can help firms deal with various kinds of information, absorb knowledge, confront all kinds of unpredictable changes and then promote technological innovation capability. Compared with male executives, female executives’ empathy is stronger and can better stimulate the communication within firms. Therefore, the promotion of female executives to organizational learning capability is more than that of
male executives (Claes, 1999). As a result, firms’ technological innovation capability will benefit from the promotion. Normally, if firms adopt R&D-intensive strategies, they have to deal with more information and absorb more knowledge. This requires a higher level of organizational learning capability to guarantee the success of technological innovation activities. In contrast, if firms do not adopt R&D-intensive strategies, they need to only maintain the daily operation and there is no requirement for a higher level of organizational learning capability. Hence, female participation in TMT is more likely to generate chemical effect with firms’ R&D-intensive strategies and form an ideal strategy fit (Miller, 1986). They will all together impose a positive impact on firms’ technological innovation capability.

Based on the above claims, hypothesis 3 and hypothesis 4 are given.

Hypothesis 3: When R&D-intensive strategy is adopted, ordinary female executives can promote firms’ technological innovation capability.

Hypothesis 4: When R&D-intensive strategy is adopted, female CEOs can promote firms’ technological innovation capability.

The relationship between competition intensity and firms’ technological innovation capability is not conclusive. Some scholars believe that the monopoly power is the important prerequisite for technological innovation. When the protection of intellectual property rights is not complete, firms will have no motivations to innovate, because they can’t enjoy the profits alone. Hence, competition intensity is negatively related to firms’ technological innovation capability (Gilbert, 2006). In contrast, other scholars believe that competition intensity is the key for firms to increase R&D expenditure. Hence, competition intensity is positively related to firms’ technological
innovation capability (Nickell, 1996; Blundell, Griffith and Van Reenen, 1999).

At present, Chinese economy is in a transition period, and the protection of intellectual property rights is not enough in this period (Choi, Lee and Kim, 1999; Hoskisson et al., 2000; Li and Atuahene, 2002). Moreover, Chinese government decided to let market play a decisive role, thus the competition will be more and more intense. Therefore, Chinese firms will not only face the risk of innovation failure, but also will face the risk of losing profit after innovation success. The overall risk is quite high.

When faced with competition, female is more risk-averse. Due to the difference of physiology, culture and information processing method, female has risk-aversion characteristic (Laborde, 1994; Hersch, 1996; Slovic, 1996; Graham, 2002). This characteristic has been proved in many researches. For example, the percentage of high-risk assets in total investment portfolios of female fund managers is less than the percentage of high-risk assets in total investment portfolios of male fund managers (Bernasek and Shwiff, 2001; Agnew et al., 2003). In addition, this characteristic has also been testified in simulated game experiments and risk-preference questionnaires (Levin et al., 1989; Prince, 1993; Barsky et al., 1997). Then when faced with competition, firms that have female participation will also show risk-aversion feature, reduce R&D investment and therefore weaken the technological innovation capability.

Based on the above claims, hypothesis 5 and hypothesis 6 are given.

Hypothesis 5: When faced with fierce competition, ordinary female executives have a negative impact on firms’ technological innovation capability.

Hypothesis 6: When faced with fierce competition, female CEOs have a negative
impact on firms’ technological innovation capability.

Choosing the appropriate innovation method is important for firms to enhance their technological innovation capability. The innovation methods can be divided into two categories: internal independent innovation and external cooperative innovation. Internal independent innovation mostly comes from the knowledge creation of individual employee (Simon, 1991). External cooperative innovation’s sources are various, including cooperation with clients (Pascale, 1984), cooperation with suppliers, direct copy of existing products (Ghoshal and Westney, 1991; Bierly and Chakrabarti, 1996a) and cooperation with research institutions (Porter, 1990).

There is no absolute good or bad choice for the five kinds of innovation methods. Firms should choose the most suitable one based on their endowments and abilities. When making the choices, firms should not only consider technical capability, clients’ need, market development, competition intensity, patent protection and so on. They should also take characteristics of TMT members into account. Hence, this paper will investigate the co-effect of female participation and innovation methods.

Based on the above analysis, hypothesis 7 and hypothesis 8 are given.

Hypothesis 7: Ordinary female executives, along with firms’ different technological innovation methods, have co-effects on firms’ technological innovation capability.

Hypothesis 8: Female CEOs, along with firms’ different technological innovation methods, have co-effects on firms’ technological innovation capability.
Figure 2. presents the analytical framework and hypotheses relationship of this article.

Figure 2. Analytical framework and hypothesis relationship.
This article uses the data collected by World Bank through a survey about 2848 Chinese firms in 2012. This survey collects the information of target firms in 2011 from various aspects: relationship between government and firms, competition, security, infrastructure, funding source, corporate governance and technological innovation. This paper mainly focuses on corporate governance and technological innovation.

At present, most of the foreign and domestic researches use big listed companies as samples, lack of attentions to SMEs. The rarity of the World Bank’s data is that most of the surveyed companies are SMEs. On one hand, shareholders or market always restricts top managers of listed companies. However, top managers of SMEs typically have more rights to do strategic decisions. Hence, they have more direct influence on firms’ technological innovation capability. On the other hand, the technological innovation capability of SMEs developed very quickly, and SMEs have become the fundamental force of innovation in China. National Development and Reform Commission, the Research Office of State Council, State Intellectual Property Right Office and Chinese Academy of Sciences all together conducted a survey about the innovation of SMEs in 2006. The results showed that 70% of technological innovation and over 80% new products development came from SMEs in China. Hence, it is very meaningful to choose SMEs as target sample in this paper.
Among 2848 surveyed firms, 1727 manufacturing firms are firstly reserved to control the industry effects. Secondly, SMEs are reserved. Finally, the missing data are dropped. 448 firms are eventually included in this paper’s sample.

**Variable Explanation**

**Dependent Variable**

- Technological Innovation Capability

About how to evaluate firms’ technological innovation capability, foreign and domestic scholars do not have consensus. To sum up, the widely used measures include: R&D indicators, patent indicators, total innovation expenditure indicators, percentage of new product sales and new product release.

R&D indicators, including R&D expenditure and R&D related employees, are the most commonly used measures to evaluate firms’ technological innovation capability. The advantages are as follows: The statistics of R&D indicators can be easily obtained and can be compared between countries and industries, due to their widely usage. Moreover, R&D data are always divided into two categories: product and production process. Because product innovation is considered to be more useful for firms to enhance performance than production process (Brouwer et al., 1993; Geroski et al., 1993), the division of R&D indicators is especially important. However, R&D indicators also have some disadvantages: R&D is a measure for innovation input. It is not explanatory for innovation output. Additionally, even only taken input measures into consideration, R&D is not comprehensive enough. Except for R&D indicators, many other innovation input factors will influence firms’ technological innovation capability, such as product design,
market analysis, employee training, fixed capital investment and so on (Felder et al., 1996).

Patent indicators, including number of patents and patent applications, are important measures for technological innovation output. The advantages of patent indicators are as follows: The data can be obtained from public sources and can be divided into different technical areas. Moreover, the patents obtained by firms can comprehensively reflect the long-term innovation capability of enterprises. However, patent indicators also have some disadvantages: Patent indicators omit many innovation outputs that have not successfully applied for patents. In addition, even the patent application is accomplished, whether the new product or new service can really make profit in market is still not decided.

Total innovation expenditure indicators, different from R&D indicators, including all of the input measures. Brouwer and Kleinknecht (1997) pointed out that R&D expenditure occupies only 25% of the total innovation expenditures. Hence, from the input aspect, total innovation expenditure is more comprehensive than R&D indicators. However, it is very difficult to measure the non-R&D indicators. Hence, the accuracy of total expenditure is not satisfying.

Percentage of new product sales is always collected by survey, which means the percentage of firms’ new products of the total revenue. It is an output measure. Percentage of new product sales has the following advantages: It can directly measure the cash flow to firms that caused by introducing new products into market. It is an effective measure of the efficiency of resources invested. Percentage of new product sales is used more and more widely in empirical studies. However, it also has a disadvantage: The
recovery ratio of survey may be low and the percentage may be a rough number, thus the accuracy of measurement may not be good.

New product release method means that to count the number of new product release information on trading or technical magazines to measure firms’ technological innovation capability. This method has been firstly used in 1982 to evaluate the relationship between firm size and firms’ technological innovation capability (Acs and Audretsch, 1993). The advantage of this method is that it can directly reflect the output of successful innovation and there is no need for professional data searchers. However, the disadvantage is that there are no agreed standards to screen the magazines. Hence, the comparison is not convincing.

Kleinknecht (2002) compared the five methods that discussed above and found out that the explanatory power of R&D indicators and patent indicators are lower than perceived. He preferred to use percentage of new product sales and new product release, because these two can directly measure the output of technological innovation. Moreover, Damanpour (1996) pointed out that product innovation is more important for SMEs. Hence, this paper uses percentage of new product sales to measure firms’ technological innovation capability. This is the dependent variable of this paper.

**Independent Variables**

- Female Participation in TMT

  In general sense, female executives include female directors, female supervisors as well as other female managers of various departments. In narrow sense, female executives refer to female CEO and female CFO. Scholars always use dummy variables
or proportionate variables to measure female participation in TMT. Table 2 presents the detail.

**Table 2**  
*Measurement for Female Participation in TMT*

<table>
<thead>
<tr>
<th>Female Participation in TMT</th>
<th>Measurement Method</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female CEO</td>
<td>Dummy Variable</td>
<td>Mohan and Chen, 2004; Levi, 2008; Gul, 2011</td>
</tr>
<tr>
<td>Female CFO</td>
<td>Dummy Variable</td>
<td>Francis et al., 2009</td>
</tr>
<tr>
<td>Female Executives (In general sense)</td>
<td>Proportionate Variable</td>
<td>Dwyer et al., 2003; Ren and Wang, 2010</td>
</tr>
<tr>
<td></td>
<td>Dummy Variable</td>
<td>Bertrand and Hallock, 2000; Krishnan and Parsons, 2008; Francoeur et al., 2008</td>
</tr>
</tbody>
</table>

On one hand, individual manager’s personal behavior and traits will affect the firms’ decision-making process (Cyert, 1963). Especially for CEOs, CEOs have big influence on firms’ technological innovation capability, because they are in charge of the daily operation of the whole firm. On the other hand, based on the upper-echelon theory (Hambrick and Mason, 1984), not only the individual manager, but also the whole TMT will influence the firms’ decision-making process. Therefore, this paper wants to investigate the impacts of ordinary female executives and female CEOs respectively, from both the general sense and the narrow sense. In addition, the data used in this paper separates the two kinds of female participation. Because the overall female participation ratio in TMT is about 54.9%, which is not a high ratio, using dummy variables can clearly distinguish the impacts of both ordinary female executives and female CEOs. There is no need to use a proportionate method. To sum up, this paper introduces two
dummy variables (ordinary female executives and female CEOs) to evaluate the female participation in TMT.

**Interaction Variables**

- **R&D Intensity**

  In order to evaluate whether a firm is R&D-intensive or not, Pérez-González (2006) used the following measurement in his study. If a firm does not announce its R&D expenditure, it is not a R&D-intensive firm, because R&D activities do not play an important role in its operation. If a firm does announce its R&D expenditure, it is a R&D-intensive firm, because R&D activities are important for its operation. This paper follows the above criterion, and introduces dummy variable “R&D intensity” to describe the strategy of firms. If a firm adopts R&D-intensive strategy, “R&D intensity” equals 1. If a firm does not adopt R&D-intensive strategy, “R&D intensity” equals 0.

- **Competition Intensity**

  Competition intensity can describe the hostility of environment (Kim et al., 1993) and the pressure on technological innovation from market (Birchall et al., 1996). This paper introduces the dummy variable “competition” to build interaction term with two main independent variables. Jaworski et al (1993) used the number of similar products of competitors to measure the competition intensity. This paper follows this criterion and introduces the dummy variable “competition”. If firms’ product faces “too many to count” similar products of competitors, “competition” equals 1. If firms’ product faces countable similar products of competitors, “competition” equals 0.

- **Technological Innovation Methods**

  As discussed above, there are mainly five kinds of technological innovation
methods: internal independent innovation, cooperation with suppliers, cooperation with clients, cooperation with research institutions, and direct copy of existing products. In order to investigate the co-effects of female participation in TMT and different innovation methods, this paper totally introduced five dummy variables to build interaction terms with independent variables. It should be noted that because some firms use none of the five kinds of innovation methods, there are five dummy variables instead of four dummy variables.

**Controlled Variables**

- **Firm Size**

  Firm size can be the proxy variable for some factors that will influence firms’ technological innovation capability, such as total resources, soft resources and organizational structure. Rizzoni (1991) believed that small firms and big firms play different role in technological innovation activities. Small firms have scarce resources, little influence on market and informal communication system (Dickson et al., 1997). All these characteristics are not good for the development of firms’ technological innovation capability. However, the flexibility and the more motivated managers of small firms can promote the firms’ technological innovation capability (Vossen, 1998). No matter the impact of firm size is positive or negative; scholars all believe that firm size will affect firms’ technological innovation capability. Hence, this paper uses firm size as one controlled variable. The two commonly used indicators are firm assets and number of firm employees (Hopkins, 1998). This paper uses number of employees as the indicator of firm size.
• Firm Age

Firm age can be the proxy variable for life cycle, accumulated resources and market experience. Sørensen and Stuart (2000) conducted a research of semi-conduct and biological firms, and found out that the higher the firm age, the more the technological innovations. In contrast, Huergo and Jaumandreu (2004) pointed out that younger firms have stronger technological innovation capability. No matter the impact of firm age is positive or negative; scholars all believe that firm age will affect firms’ technological innovation capability. Hence, this paper uses firm age as one controlled variable. The length between the establishment year and 2011 is calculated to measure firm age.

• Revenue Growth

In general, the firms with higher growth will have enough resources and motivations to invest in R&D, and further promote firms’ technological innovation capability and create growth opportunities in future (Liu and Liu, 2007). Hence, this paper selects revenue growth as control variable. Ryan and Wiggins (2002) chooses book-to-market ratio to measure the growth of firms. Wu (1999) pointed out that revenue growth is the key factor for the growth of firms. Because the sample of this paper is SMEs that do not have the data of book-to-market ratio, this paper uses CAGR from 2009 to 2011 to measure the growth of firms.

• Percentage of Technical Employees

The employment of technical employees can be used to assess the knowledge intensity and firms’ capability to absorb knowledge (Koschatzky and Zenker, 1999). Hadjimanolis (2000) declared that technical employees represent the internal innovation resources of firms, and it can be accumulated with time. Hence, percentage of technical
employees is thought to be the determinant of firms’ technological innovation capability. This paper uses percentage of technical employees as one controlled variable.

- **Employee Education**

  Hadjimanolis (2000) believed that highly educated employees are also an internal innovation resource of firms. Hence, highly educated employees are considered to be a determinant of firms’ technological innovation capability. This paper uses the employee education level as one controlled variable and uses the percentage of employees with middle school or above education level to measure the employee education level.

  To sum up, Table 3 presents the explanations for all the variables in this paper.
## Variable Explanations

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Variable Label</th>
<th>Variable Name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
<td>New Pro</td>
<td>Technological Innovation Capability</td>
<td>Percentage of new product sales of total revenue</td>
</tr>
<tr>
<td>Independent Variable</td>
<td>Fem CEO</td>
<td>Female CEO</td>
<td>Fem CEO=1, CEO is female; Fem CEO=0, CEO is male</td>
</tr>
<tr>
<td></td>
<td>Fem TMT</td>
<td>Ordinary Female Executives</td>
<td>Fem TMT=1, TMT has female executives, excluded female CEO; Fem TMT=0, TMT has no female executives, excluded female CEO</td>
</tr>
<tr>
<td>Interaction Variable</td>
<td>R&amp;D Intensity</td>
<td>R&amp;D Intensity</td>
<td>R&amp;D Intensity=1, firm reported R&amp;D expenditure; R&amp;D Intensity=0, firm did not report R&amp;D expenditure</td>
</tr>
<tr>
<td></td>
<td>Competition</td>
<td>Competition</td>
<td>Competition=1, there are too many to count similar products; Competition=0, there are countable similar products</td>
</tr>
<tr>
<td></td>
<td>Intra-firm</td>
<td>Internal Independent Innovation</td>
<td>Intra-firm=1, firm adopted internal independent innovation; Intra-firm=0, firm adopted other innovation methods</td>
</tr>
<tr>
<td></td>
<td>Supplier</td>
<td>Cooperation with Suppliers</td>
<td>Supplier=1, firm cooperated with suppliers to innovate; Supplier=0, firm adopted other innovation methods</td>
</tr>
<tr>
<td></td>
<td>Client</td>
<td>Cooperation with Client</td>
<td>Client=1, firm cooperated with clients to innovate; Client=0, firm adopted other innovation methods</td>
</tr>
<tr>
<td></td>
<td>Institution</td>
<td>Cooperation with Research Institutions</td>
<td>Institution=1, firm cooperated with research institutions to innovate; Institution=0, firm adopted other innovation methods</td>
</tr>
<tr>
<td></td>
<td>Copy</td>
<td>Copy Existing Products</td>
<td>Copy=1, firm copied existing products; Copy=0, firm adopted other innovation methods</td>
</tr>
<tr>
<td>Controlled Variable</td>
<td>Size</td>
<td>Firm Size</td>
<td>Number of employees</td>
</tr>
<tr>
<td></td>
<td>Firm Age</td>
<td>Firm age</td>
<td>Number of years from establishment year to 2011</td>
</tr>
<tr>
<td></td>
<td>Rev Growth</td>
<td>Revenue Growth</td>
<td>CAGR of revenue, from 2009 to 2011</td>
</tr>
<tr>
<td></td>
<td>Tech Employee</td>
<td>Percentage of Technical Employees</td>
<td>Percentage of technical employees of total employees</td>
</tr>
<tr>
<td></td>
<td>Employee Edu</td>
<td>Employee Education</td>
<td>Percentage of employees with secondary or higher education level of total employees</td>
</tr>
</tbody>
</table>
Model Explanation

This article uses many interaction terms. If all the interaction terms are all included in one model to regress, the multicollinearity problem will be serious. To solve this problem, this paper introduces interaction terms step by step. Therefore, this paper totally uses six models.

Model 1 is shown as follows, including only controlled variables, to observe the effect of the controlled variables on dependent variable.

New Pro = $\alpha + \beta_1$Size $+ \beta_2$FirmAge $+ \beta_3$RevGrowth $+ \beta_4$TechEmployee $+ \beta_5$EmployeeEdu $+ \epsilon$

Model 2 is shown as follows, female participation variables are added into this model to observe the impact of ordinary female executives and female CEOs on firms’ technological innovation capability respectively. According to model 2, if hypothesis 1 is supported, the coefficient of variable “Fem TMT” will be significant positive. If hypothesis 2 is supported, the coefficient of variable “Fem CEO” will be significant positive.

New Pro = $\alpha + \beta_1$FemTMT $+ \beta_2$FemCEO $+ \beta_3$Size $+ \beta_4$FirmAge $+ \beta_5$RevGrowth $+ \beta_6$TechEmployee $+ \beta_7$EmployeeEdu $+ \epsilon$

Model 3 is shown as follows, variable “R&D Intensity” is added into model to build interaction terms with female participation. The purpose is to observe the impact of ordinary female executives and female CEOs on firms’ technological innovation capability, when firms adopt R&D-intensive strategies. According to model 3, if hypothesis 3 is supported, the coefficient of variable “Fem TMT * R&D Intensity” will be significant positive. If hypothesis 4 is supported, the coefficient of variable “Fem CEO” R&D Intensity” will be significant positive.
\[
\text{New Pro} = \alpha + \beta_1 \text{FemTMT} + \beta_2 \text{FemCEO} + \beta_3 \text{FemTMT} \times R \& D\text{Intensity} \\
+ \beta_4 \text{FemCEO} \times R \& D\text{Intensity} + \beta_5 R \& D\text{Intensity} + \beta_6 \text{Size} \\
+ \beta_7 \text{FirmAge} + \beta_8 \text{RevGrowth} + \beta_9 \text{TechEmployee} + \beta_{10} \text{EmployeeEdu} + \epsilon
\]

Model 4 is shown as follows, variable “Competition” is added into model to build interaction terms with female participation. The purpose is to observe the impact of ordinary female executives and female CEOs on firms’ technological innovation capability when faced with fierce competition. According to model 4, if hypothesis 5 is supported, the coefficient of variable “Fem TMT * Competition” will be significant positive. If hypothesis 6 is supported, the coefficient of variable “Fem CEO*Competition” will be significant positive.

\[
\text{New Pro} = \alpha + \beta_1 \text{FemTMT} + \beta_2 \text{FemCEO} + \beta_3 \text{FemTMT} \times \text{Competition} \\
+ \beta_4 \text{FemCEO} \times \text{Competition} + \beta_5 \text{Competition} + \beta_6 \text{Size} \\
+ \beta_7 \text{FirmAge} + \beta_8 \text{RevGrowth} + \beta_9 \text{TechEmployee} + \beta_{10} \text{EmployeeEdu} + \epsilon
\]

Model 5 is shown as follows, variable “innovation methods” are added into model to build interaction terms with female participation. The purpose is to investigate the co-effects of ordinary female executives and different innovation methods on firms’ technological innovation capability. According to model 5, if hypothesis 7 is supported, at least one of the coefficients of variables “Fem TMT * Intra-firm”, “Fem TMT * Supplier”, “Fem TMT * Client”, “Fem TMT * Institution”, and “Fem TMT * Copy” will be significant positive.

\[
\text{New Pro} = \alpha + \beta_1 \text{FemTMT} + \beta_2 \text{FemCEO} + \beta_3 \text{FemTMT} \times \text{Intra-firm} \\
+ \beta_4 \text{FemTMT} \times \text{Supplier} + \beta_5 \text{FemTMT} \times \text{Client} + \beta_6 \text{FemTMT} \times \text{Institution} + \beta_7 \text{FemTMT} \times \text{Copy} \\
+ \beta_8 \text{Intra-firm} + \beta_9 \text{Supplier} + \beta_{10} \text{Client} + \beta_{11} \text{Institution} + \beta_{12} \text{Copy} + \beta_{13} \text{Size} \\
+ \beta_{14} \text{FirmAge} + \beta_{15} \text{RevGrowth} + \beta_{16} \text{TechEmployee} + \beta_{17} \text{EmployeeEdu} + \epsilon
\]

Model 6 is shown as follows, variable “innovation methods” are added into model to build interaction terms with female participation. The purpose is to investigate
the co-effects of female CEOs and different innovation methods on firms’ technological innovation capability. According to model 6, if hypothesis 8 is supported, at least one of the coefficients of variables “Fem CEO * Intra-firm”, “Fem CEO * Supplier”, “Fem CEO * Client”, “Fem CEO * Institution”, and “Fem CEO * Copy” will be significant positive. 

\[
\text{New Pro} = \alpha + \beta_1 \text{FemTMT} + \beta_2 \text{FemCEO} + \beta_3 \text{FemCEO} \times \text{Intra-firm} + \beta_4 \text{FemCEO} \times \text{Supplier} + \beta_5 \text{FemCEO} \times \text{Client} + \beta_6 \text{FemCEO} \times \text{Institution} + \beta_7 \text{FemCEO} \times \text{Copy} + \beta_8 \text{Intra-firm} + \beta_9 \text{Supplier} + \beta_{10} \text{Client} + \beta_{11} \text{Institution} + \beta_{12} \text{Copy} + \beta_{13} \text{Size} + \beta_{14} \text{FirmAge} + \beta_{15} \text{RevGrowth} + \beta_{16} \text{TechEmployee} + \beta_{17} \text{EmployeeEdu} + \epsilon
\]

Empirical Results

In this paper, STATA12.0 statistical analysis software is used for empirical analysis.

Descriptive Analysis

Table 4 presents the descriptive statistics of the variables used in this paper. Among all the 448 sample firms, the average of percentage of new product sales is about 20% and most of firms’ percentage of new product sales is below 30%. The difference between the maximum and the minimum is 64%. This means that the overall level of technological innovation capability of SMEs in China is low and the gap between firms and firms is huge.

In general, the phenomena those male executives are more than female executives can be explained from two aspects: demand and supply. On the demand side, firms have gender discrimination (Altonji and Blank, 1999; Neumark et al., 1996), thus firms will be inclined to male candidates when they select executives. On the supply side, female puts too much energy in family, thus influence their investment in human capital and their career choices (Mincer and Polachek, 1974). In the sample of this article, percentage of firms with ordinary female executives’ participation is about 55%.
However, the percentage of firms with female CEOs is only 7%. It can be seen that though more and more women are going to work and enter TMT of firms, they are still unlikely to serve as senior managers, such as CEOs. Thus, the impact of female participation in TMT on firms’ technological innovation capability should be explained in detail in the following regression analysis.

In addition, it is worth noting that about 73% of the SMEs are faced with fierce competition. Hence, this paper’s investigation of the impact of female participation in TMT on firms’ technological innovation capability in a competitive environment is very meaningful. Moreover, over half of the sample firms adopt the internal independent innovation method and the direct copy of existing products. Less than half of the sample firms choose to innovate with suppliers, clients and research institutions. Cooperation with research institutions is the least chosen one. Thus, are the firms’ choices reasonable? It will be answered in the following regression analysis.

About the controlled variables, the average firm size is about 230 employees. In addition, because the sample firms are manufacturing firms, the percentage of technical employees is quite high.
Table 4.

**Descriptive Statistics of Variables**

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<tr>
<th>Variable</th>
<th>Obs</th>
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<th>Std. Dev.</th>
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<th>25% Per</th>
<th>50% per</th>
<th>75% per</th>
<th>Max</th>
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**Correlation Analysis**

Table 5 presents the correlation statistics of variables of this paper. Female CEO is positively correlated with percentage of new product sales ($r=0.23$, $p<0.01$), which is coherent with the hypothesis. However, ordinary female executives are not correlated with percentage of new product sales, which is not coherent with the hypothesis. This may caused by the offset of advantages and disadvantages of female participation, and should be testified by the following regression analysis. R&D intensity is positively correlated with percentage of new product sales ($r=0.10$, $p<0.05$), because R&D-intensive firms invest more in R&D activities. Competition is negatively correlated with percentage of new product sales ($r=-0.12$, $p<0.05$), because when faced with fierce competition, firms do not have a stable external environment to innovate and do not have
the motivations to innovate due to the poor protection of the innovation results. In addition, cooperation with suppliers is positively correlated with percentage of new product sales (r=0.11, p<0.05). Direct copy of existing products is negatively correlated with percentage of new product sales (r=-0.12, p<0.05).

Table 5.
*Correlative Statistics of Variables*

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Note: significance at: ***p < 0.01, **p < 0.05, *p < 0.1 (two-tailed)
**Hypothesis Test**

Before the formal regression analysis, the analysis of the sample companies reveals that the firms with ordinary female executives also employ more female workers. This implies that sample firms’ appointment of female executives is more likely to be caused by no gender discrimination. Thus, the impact of ordinary female executives on firms’ technological innovation capability is also more likely to be caused by their female traits. However, the firms with female CEOs do not employ more female workers. This means that the female CEOs are employed for their non-female or unique characteristics. Thus, the impact of female CEOs on firms’ technological innovation capability is more likely to be caused by female CEOs’ non-female or unique traits. The above discussion makes the regression results more convincing and reliable.

All the variables’ VIFs are below 10, and the average VIF for all the models is below 3 in this paper. There is no serious multicollinearity problem. Because female participation in TMT is normally not affected by firms’ technological innovation capability, thus there is no serious endogeneity problem. The heteroscedasticity test reveals that there is heteroscedasticity problem for some models, thus these models use robust regression. Table 6 presents the regression results of this paper.
Table 6.
Regressions of Female Participation in TMT and Technological Innovation Capability

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 Coefficient (Std. Dev.)</th>
<th>Model 2 Coefficient (Std. Dev.)</th>
<th>Model 3 Coefficient (Std. Dev.)</th>
<th>Model 4 Coefficient (Std. Dev.)</th>
<th>Model 5 Coefficient (Std. Dev.)</th>
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<td></td>
</tr>
<tr>
<td>Size</td>
<td>-0.0005 (0.0012)</td>
<td>-0.0002 (0.0011)</td>
<td>-0.0006 (0.0012)</td>
<td>-0.0007 (0.0011)</td>
<td>-0.0002 (0.0010)</td>
<td>-0.0004 (0.0011)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>-0.0499 (0.0786)</td>
<td>-0.0372 (0.0763)</td>
<td>-0.0403 (0.0749)</td>
<td>0.0006 (0.0764)</td>
<td>-0.0335 (0.0741)</td>
<td>-0.0376 (0.0759)</td>
</tr>
<tr>
<td>Rev Growth</td>
<td>0.0117 (0.0296)</td>
<td>0.0002 (0.0266)</td>
<td>-0.0004 (0.0268)</td>
<td>0.0060 (0.0282)</td>
<td>-0.0003 (0.0251)</td>
<td>-0.0022 (0.0261)</td>
</tr>
<tr>
<td>Tech Employee</td>
<td>-0.0749 (0.0468)</td>
<td>-0.0397 (0.0460)</td>
<td>-0.0341 (0.0466)</td>
<td>-0.0341 (0.0454)</td>
<td>-0.0238 (0.0495)</td>
<td>-0.0306 (0.0528)</td>
</tr>
<tr>
<td>Employee Edu</td>
<td>0.0295 (0.0257)</td>
<td>0.0331 (0.0260)</td>
<td>0.0293 (0.0259)</td>
<td>0.0172 (0.0266)</td>
<td>0.0306 (0.0258)</td>
<td>0.0315 (0.0264)</td>
</tr>
<tr>
<td>Constant</td>
<td>24.9821* (3.8777)</td>
<td>22.2549** (3.7773)</td>
<td>22.9309** (3.9888)</td>
<td>25.4224** (4.2578)</td>
<td>22.1202** (4.5567)</td>
<td>22.0333** (4.5491)</td>
</tr>
<tr>
<td>Obs</td>
<td>448</td>
<td>448</td>
<td>448</td>
<td>448</td>
<td>448</td>
<td>448</td>
</tr>
<tr>
<td>R²</td>
<td>0.0118</td>
<td>0.0600</td>
<td>0.0845</td>
<td>0.0789</td>
<td>0.1426</td>
<td>0.0990</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.0006</td>
<td>0.0450</td>
<td>0.0635</td>
<td>0.0578</td>
<td>0.1087</td>
<td>0.0634</td>
</tr>
<tr>
<td>F Value</td>
<td>1.37</td>
<td>3.17***</td>
<td>3.52***</td>
<td>3.48***</td>
<td>3.85***</td>
<td>2.52***</td>
</tr>
</tbody>
</table>

Note: significance at: ***p < 0.01, **p < 0.05, *p < 0.1 (two-tailed)
Model 1 only includes the controlled variables. The results show that all five controlled variables have no significant impact on firms’ technological innovation capability. The possible explanation is that though the choice of the controlled variables is supported by theory and the controlled variables are widely used in scholars’ researches, in most time they are used to explain the innovation input. However, this paper uses innovation output as dependent variable and this may compromise the explanatory power of these five controlled variables. Moreover, though the significance of the controlled variables is not enough, the regression signs of them are consistent with the hypothesized signs. Hence, the regression results in model 1 are reasonable to some extent.

Model 2 mainly investigate the overall impact of female participation in TMT on firms’ technological innovation capability. The results show that generally female CEOs have significant positive relationship with firms’ technological innovation capability ($r=12.31, p<0.01$), which means hypothesis 2 is supported. However, ordinary female executives are not significantly related with firms’ technological innovation capability, which means that hypothesis 1 is rejected. The possible explanation is that on one hand, ordinary female executives bring different points of view, different experience and different methods to solve problem into TMT. This is the advantage. On the other hand, they are also less confident and more risk-averse than male executives. Hence, they may lose some innovation opportunities. This is the disadvantage. The advantage and the disadvantage of ordinary female executives offset each other, and the overall effect is thus insignificant. In addition, the voice of ordinary female executives may be silenced in Chinese firms’ TMT, thus there is no actual promotion of TMT’s heterogeneity.
Model 3 introduces the R&D intensity variable to investigate the influence of female participation in TMT on firms’ technological innovation capability when firms adopt R&D-intensive strategies. The results imply that the interaction term of ordinary female executives and R&D intensity is significantly and positively related with firms’ technological innovation capability ($r=7.00$, $p<0.01$), which means that hypothesis 3 is supported. This result implies that ordinary female executives can truly form a strategy fit with R&D-intensive strategy, thus generate a synergy effect on firms’ technological innovation capability. In contrast, the interaction term of female CEO and R&D intensity has no significant influence on dependent variable, which means that hypothesis 4 is rejected. The possible explanation is that the positive synergy comes from the stimulation of organizational learning capability caused by the better communication skills and participative leadership style of female managers. However, female CEO is in charge of the daily operation of the whole firm, thus they may intentionally choose a masculine leadership style. Female CEOs abandon their female traits in CEO positions and naturally can’t generate synergy effect with R&D-intensive strategy. It is worth noting that ordinary female executives have significant negative relationship with firms’ technological innovation capability in this model ($r=-6.12$, $p<0.01$), which does not exist in model 2. The possible explanation is that the interaction term of ordinary female executives and R&D intensity separates the advantage of ordinary female executives, and the disadvantage of ordinary female executives is left. This also verifies the explanation of the rejection of hypothesis 1.

Model 4 introduces the competition intensity variable to observe the effects of female participation in TMT on firms’ technological innovation capability when faced
with fierce competition. The results show that the interaction term of ordinary female executives and competition is not significantly related with the dependent variable, which means hypothesis 5 is rejected. The possible explanation is that though ordinary female executives will not be willing to invest resources in R&D when faced with fierce completion due to their risk-aversion characteristic, they can’t effectively show this negative influence because they do not have substantial effects on the decision-making process of technological innovation. Whether to implement innovation activities is dependent on the will of senior managers, such as CEO. Hence, the risk-aversion characteristic of ordinary female executives does not truly affect the firms’ technological learning capability. It is worth noting that the interaction term of female CEOs and competition is significantly and negatively correlated with dependent variable (r=11.15, p<0.1), which means the hypothesis 6 is rejected and the direction is opposite. The possible explanation is that given the fact that gender discrimination still exists in workplace in China, if a female executive becomes CEO, she must have better working abilities, more abundant working experience and less risk-averse characteristics even compared with male executives. And after she becomes the CEO, her success in career will then adversely strengthen her preference of risk, thus means there is self-selection phenomena. Just as Eagly et al. (2007) and Nekby (2008) mentioned, the women who act actively in a traditional male-dominated environment are always more confident and competitive. Therefore, when faced with fierce competition, female CEOs are more likely to invest resources in innovation to gain competitive advantages through the enhancement of technological innovation capability.
Model 5 introduces the innovation methods variables, to investigate the co-effects of female participation and different technological innovation methods. The results show that the interaction term of ordinary female executives and cooperation with research institutions has a significant positive relationship with firms’ technological innovation capability ($r=6.98$, $p<0.01$), and the interaction term of ordinary female executives and direct copy of existing products has a significant negative relationship with firms’ technological innovation capability ($r=-10.47$, $p<0.01$), which means that hypothesis 7 is supported. Thus, ordinary female executives indeed have co-effects with different innovation methods on the dependent variable. The possible explanation is that as discussed above, on one hand, female participation increases the heterogeneity of TMT, thus make the interpretation of information more various and comprehensive. On the other hand, ordinary female executives bring better internal communication and more participative leadership style into the firm, and consequently increase the firms’ organizational learning capability. When firms cooperate with research institutions to innovate, they have to learn a lot of knowledge and process a lot of information during the study process. Whether the innovation will success or not depends on the accuracy of the information interpretation of firms. All these require the innovation subject to have higher organizational learning capability.

Consequently, the firms with ordinary female executives will do better when implement innovation activities with research institutions, because of their higher organizational learning capability. In contrast, when firms directly copy the existing products, the stimulation of organizational learning capability of ordinary female executives is not necessary, because the copy of existing products is easy for the firms to
implement and there is no need for interpreting new knowledge. In this situation, the female participation only increases the complexity of decision-making process. Therefore, it is not strange to observe a negative co-effect of ordinary female executives and direct copy of existing products.

Model 6 also introduces the innovation methods variables to investigate the co-effects of female CEO and different innovation methods. The results show that the interaction term of female CEO and innovation methods is not related with firms’ technological innovation capability, which means that the hypothesis 8 is rejected. The possible explanation is that female CEOs, as the decision makers, do not actually participate in the implementation process of innovation activities. Hence, their co-effects with different innovation methods are difficult to be observed.
CHAPTER 5  
CONCLUSION, IMPLICATIONS AND LIMITATIONS

This paper uses the SMEs in China as sample to analyze the impact of female participation in TMT on firms’ technological innovation capability. Four conclusions are drawn. (a) Generally, female CEOs can significantly promote firms’ technological innovation capability. (b) When R&D-intensive strategy is adopted, ordinary female executives can significantly promote firms’ technological innovation capability. (c) When faced with fierce competition, female CEOs have a significant positive impact on firms’ technological innovation capability. (d) Ordinary female executives, along with different technological innovation methods, have co-effects on firms’ technological innovation capability.

The main contributions of this paper are as follows:

Firstly, the existing studies related to TMT members’ gender characteristic mainly analyze the impact of female participation in TMT on the decision-making and implement process of technological innovation. However, a direct analysis of female executives’ impact on technological innovation output is still a blank. This paper fills this research gap.

Secondly, most of the existing studies use big listed firms as sample. However, this paper uses SMEs as sample. Compared to top managers of listed companies, top managers in SMEs have bigger rights to make the decisions about innovation strategies. Hence, they also have more direct influence on firms’ technological innovation capability. This makes the conclusions of this paper more convincing and reasonable.

Thirdly, this paper separates female participation into two categories, ordinary female executives and female CEOs, to investigate the impact of them on firms’
This paper also provides some implications for the technological innovation practice in China. Firstly, firms should not have gender discrimination when screening potential CEO candidates. Additionally, R&D-intensive firms should be inclined to absorb more female executives into TMT, in order to take the advantage of female executives’ stimulation to organizational learning capability to realize synergy. Moreover, firms should appoint suitable female candidates as CEO during tough time. Finally, it is crucial to select the suitable innovation method. If firms have ordinary female executives in their TMT, they should take more cooperation with research institutions and should avoid copying existing products directly.

Of course, this paper has some limitations. Firstly, this paper’s data only cover one year. More years’ data should be included into the future research to testify whether above conclusions can hold in long-term. Secondly, more features of female executives should be included to get a more comprehensive picture of the impact of female participation in TMT on firms’ technological innovation capability, such as age, education level, working experience, social capital and so on. Moreover, except for manufacturing industry, more industries should be studies in future to make comparisons between industries. Finally, this paper simplifies the relationship between female participation in TMT and firms’ technological innovation capability. The real relationship is more complex. Some moderating and mediating variables should be included into the models in future researches.
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