VOLUME - 12, ISSUE - 09, SEPTEMBER - 2023 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Economics

DETERMINATES OF R&D INVESTMENT AND INTENSITY FOR FIRMS IN CHINA

Li Yang P.hd Student North Chiangmai University Innovation College

ABSTRACT This study aims to conduct a systematic discussion on the factors influencing R&D decisions for firms in China. In the paper, the explanatory factors of the literature are grouped into four categories: resource endowment, equity structure, business strategy, and risk-taking characteristics, while all of the factors are used to verify the effects on two kinds of indicators, including R&D actions and R&D intensity. Moreover, this study also includes two influential factors specialized to mainland China - the state-owned capital and Taiwan, Hong Kong, and Macao capital, and analyzed their impact on the two types of R&D investment decisions. In the empirical analysis, 2,679 observations from 893 manufacturers are used to conducts a heterogeneous diffusion model with panel data of the audio-visual equipment manufacturing industry from 2014 to 2016 in China. The results show that the impact of the four types of factors on R&D intensity was mainly in line with expectations, delivering results in past research for China's scenario. However, the impacts from the four types of factors on the initiative of R&D behavior are insignificant, indicating that there is still a lack of knowledge on the determinants. In addition, although the proportion of national capital could reduce the R&D intensity of manufacturers, it will increase the possibility of R&D behaviors. Same with foreign capital, the capital from Taiwan, Hong Kong, and Macao can also increase the R&D intensity.

KEYWORDS : R&D investment; R&D intensity; Panel data

1. INTRODUCTION

Innovation has been regarded as an essential means for manufacturers to create competitive advantage since Schumpeter (1934) proposed innovation as the driving factor of economic development (Stock et al., 2002; Brown and Eisenhardt, 1995). Understanding the factors that influence manufacturers' R&D and innovation helps policymakers formulate the science and technology and innovation policies of countries (Michie, 1998; Asheim and Isaksen, 1997). It also allows manufacturers to choose alliance partners effectively (De Propris, 2000). Therefore, it has attracted scholars to study the antecedent variables of R&D investment for manufacturers (Sciascia et al., 2015; Guzzini and Iacobucci, 2014; Anwar and Sun, 2013; Becheikh et al., 2006).

The government of Mainland China started the development of technology and technology as early as the 1980s. Since the "Decision of the Central Committee of the Communist Party of China on the Reform of the Science and Technology System" in 1985, China has vigorously promoted the R&D of science and technology. Especially in the information-related industries, China launched the 863 Plan to cooperate with advanced countries in 1987. Later, in the 7th, 8th, and 9th Five-Year Plans, information technology was important (Chow, 2007). Under the vigorous promotion of the public sector, China's research and practical development funding increased from 128.8 billion yuan in 2002 to 1301.56 billion yuan in 2014. Its share of GDP increased from 1.07% to 2.05%. Recently, China starts to face the problem of weak growth in output and corporate R&D investment (Chen and Yu, 2007). In the 11th to 13th Five-Year Plan, the Chinese government has listed innovation and development as a critical development project and the ratio of research and development expenditure to gross domestic product (GDP) as a key development indicator. It is expected to push forward the industrial transformation, promote the change of economic growth mode, and develop the independent innovation ability of private enterprises.

Studies in the past explored the influencing factors of manufacturers' R&D behaviors and attempted to provide a better understanding of it. However, such sort of research still has the following gaps. Firstly, these studies are mainly for the relatively mature economies like Europe and America. The research results may not apply to the context of mainland China (Tan and Peng, 2003). The institutional environment of China still has many restrictions on R&D investment, which includes financing difficulties, intermediary institutions (such as universities and laboratories) incompletion, and the legal protection of intellectual property rights insufficiency (Zhu, Wittmann, and Peng, 2011). Secondly, most of the past related researches explored the factors affecting the R&D intensity or total R&D expenditure. Only a few focused on the decision of the R&D activity adoption. Thirdly, a firm's R&D investment may be affected by others, such as the diffusion effect (Rodriguez, 2013) or the reference effect (Lim, 2015). However, past studies have rarely controlled or excluded the impact of other manufacturers. Given the need for a deeper understanding of the factors that influence R&D investment for China's manufacturers academically and practically, this study attempt to fill the gap above-mentioned. This study reviews the past research and divides the determinants of R&D investment into four categories: resource endowment, equity structure, business strategy, and risk-taking factors. It then tries to use integrated analysis to test the suitability of applying the experience of European and American in the context of China.

Furthermore, this research divides the manufacturer's R&D investment decision into whether to start investing in R&D and how much to invest in R&D, operationalized into two different dependent variables, namely, taking R&D actions and R&D intensity to test the past research institutes. It will be used to examine whether the determinants of R&D investment can predict the R&D actions of mainland manufacturers. At the same time, this study adopts the panel data regression, and the heterogeneous diffusion model. In addition to further clarifying the similarities and differences between the antecedent factors on the two R&D investment decisions, the two analytical methods control the influence of other manufacturers to improve the validity of the research result.

2. Literature Reviews

Managers use resource investment as R&D expenditure to respond to threats and opportunities brought by environmental changes (Cohen and Levinthal, 1989), and develop new technologies as an important means to establish and maintain a competitive advantage of manufacturers (Brown and Eisenhardt, 1995; Stock et al., 2002). Therefore, many studies explore the influencing factors of manufacturers' R&D, and trying to predict the success of innovation (Rothwell, 1992).

Although Chinese manufacturers used imitation and low-cost advantages to penetrate the market (Li and Gao, 2011; Gao, 2010). However, due to the slowdown in economic growth in

recent years, the government has actively promoted industrial upgrading and encouraged enterprises to conduct R&D and innovation (Dobson and Safarian, 2008; Minagawa, Trott, and Hoecht, 2007). Numerous studies have begun to study the influencing factors of R&D and innovation (e.g. Gao and Hafsi, 2015; Zhou, 2014; Yi and Li, 2015; Sun, 2015; Wang and Zhang, 2014). It is identified that the influencing factors of manufacturer R&D and innovation involve four categories, namely, manufacturer's resource endowment, shareholding structure, business strategy, and risk-taking. In the meanwhile, the manufacturer's decision on R&D investment involves two types, namely, R&D actions and R&D intensity (Tavassoli, 2015).

Resources are both facilitators and barriers of Innovation behavior. R&D requires a large investment of resources and has a high risk of failure. It is difficult for firms who lack resources to conduct R&D (Galende and Su'arez, 1999). Firms lacking sufficient resources to bear the cost of failure have no motivation and willingness to invest in R&D. (Tsai, 2001; Giudici and Paleari, 2000). As for the resource variables, firm size is regarded as an effective measure (Tsai, 2001). After Schumpeter (1934, 1942) pointed out that new venture is an important source of creativity and entrepreneurship, firm size has become the most common predictive variable for firm innovation (Becheikh et al., 2006). Due to large-scale firms not only represent resources, they also represent that they can achieve economic scale in R&D (Stock et al., 2002). Although small companies may have better R&D performance (Love and Ashcroft, 1996), large companies still have higher R&D investments. Accordingly, it is believable that the firm scale positively correlates to R&D investment.

The debt-to-asset ratio can be regarded as an inverse indicator of the potential slack of a manufacturer (potential slack; Bourgeois, 1981). When the debt-to-asset ratio of a manufacturer is lower, the more it can borrow funds from external sources at low cost to support R&D (Sun, 2015; Wang, Zhang, 2014). When the debt-to-asset ratio of a firms becomes higher, it will not only make it difficult for the firms to raise funds by borrowing, but external creditors will also increase the degree of supervision of the firm, restricting the manufacturer from investing in high-risk R&D projects (Giudici and Paleari, 2000). Thus, the debt-to-asset ratio of firms is negatively correlated with R&D investment.

The impact of the shareholding structure on R&D investment mainly came from foreign investment. In the part of corporate governance, foreign investment is generally considered to have higher ability and motivation to encourage manufacturers to invest in research and development. In order to ensure the return of their investment, foreign investment will appoint more knowledgeable and capable directors and supervisors, and introduce international accounting and auditing systems. It will create corporate governance capabilities, and encourage joint venture companies to invest in research and development for firms (Choi, Lam, Sami, and Zhou, 2013; Choi, Lee, and Williams, 2011). In addition, the foreign parent company usually has superior technology and knowledge, which can be transferred to a local joint venture company (Bishop and Wiseman, 1999; Choi et al., 2011). When the proportion of foreign equity is higher, the incentives for foreign investment to improve corporate governance or transfer technology and knowledge are higher. Therefore, the proportion of foreign equity is expected to positively correlate with the R&D investment of manufacturers.

For China, capital from Taiwan, Hong Kong, and Macau has similar effects to other foreign capital. As the economic development of these three places is earlier and the governance system is relatively complete, the advantages can encourage joint ventures to invest in research and development. At the same time, the firms also own advantages in technology, market, and management knowledge. Therefore, the effect of corporate governance and knowledge transfer will also be improved. In addition, firms of Taiwan, Hong Kong, and Macao have a smoother communication with China due to similar cultures and languages/ which makes Taiwan, Hong Kong, and Macao manufacturers more motivated to set up R&D centers in the mainland, and are more likely to make R&D investment and transfer Scientific and technological knowledge (Lu and Liu, 2004).

According to Porter (1980), differentiation and cost leadership are the two most common business strategies. The differentiation strategy is to increase profitability by increasing a small amount of cost, creating higher utility of the products, and selling it at a higher price to consumers. Differentiation strategy encourages investment and R&D activities (Beneito, 2003) and the new technologies, in turn, increase the utility and price of products and create a higher competitive advantage (Zahra, 1993).The cost leadership strategy refers to that firms use various cost-reduction efforts, such as the production of standardized products, the economies of scale in mass production, the accumulation of learning curves, etc. So that their products can reduce costs as much as possible while maintaining consumer utility to improve profitability. Therefore, contrary to the situation of the differentiation strategy, when firms follow the cost leadership strategy, in order to avoid the increase in cost and erode its profitability, they will try to limit R&D investment (Porter, 1980; Zahra, 1993). Therefore, the cost leadership strategy is negatively related to the manufacturer's R&D investment.

Risk-taking is different from the other three types of factors, as it is based on the behavior theory of the firm (Cyert and March, 1963). It is believed that certain firm-level variables will affect the risk-taking behavior (or risk appetite) of senior managers. When the manager's risk appetite increases, managers are more willing to invest in R&D (Yi and Li, 2015). Among them, the factors considered to have the most influence on R&D are slack resources and the gap between performance and performance aspirations (Greve, 2003). Cyert and March (1963) believes that firms will compare the gap between actual performance and expected level. When the performance of the manufacturer is lower than expected, they will seek various methods to achieve the performance target. Thus, the firm will have higher risk-taking behavior and investment for high-risk and high-reward R&D projects. When the firm's performance is better than expected, the possibility of organizational change will be low and therefore reduced (Greve, 1998). When manufacturers happen to achieve their goals, they tend to maintain the status quo, and their R&D investment will remain at the current level (Cyert and March, 1963; Levithal and March, 1981). Therefore, the difference between a manufacturer's actual performance and its expected level is negatively correlated with R&D investment. Cyert and March (1963) also pointed out that the company's surplus resources will make senior managers relax their control over the organization and allow higher-risk experiments and research and development (Bourgeois, 1981; Greve, 2003). In addition, the surplus resources will also make high-level managers incline to use these unused resources. R&D investment is a common practice (Penrose, 1959). Therefore, the manufacturer's surplus resources are positively correlated with R&D investment.

3. METHODOLOGY

3.1 Data Sources

This study uses the ICT manufacturing firms in the Chinese Industrial Enterprise Database as the panel data sample during 2014~2016. The three-digit industry classification code was used to identify the research samples. The original sample number of the industry was 4,728. In order to construct

panel data, we used company codes and names for comparison, and selected vendors that existed from 2013 to 2017. In order to delete a small number of abnormal data, we mainly follow the procedures of Cai and Liu's (2009) to clean up the research data. The final research sample of this study is balanced panel data over a three-year period, including 893 manufacturers and a total of 2,679 observations.

3.2 Analysis Method

In order to compare the similarities and differences between the R&D actions and the influencing factors of R&D intensity, we adopt two different analysis methods. In the model for predicting R&D intensity, in order to remove the influence of manufacturers that have not invested in R&D activities, we follow the practice of Becheikh, Landry, and Amara, (2006), and only use manufacturers that have invested in R&D activities as a sample. Since we use regression analysis of panel data, the estimation method of this type of analysis depends on the existence of autocorrelation, heteroscedasticity, and temporal or spatial dependence (Wooldridge, 2002; Hoechle, 2007).

We used the Wooldridge test to test first-order autocorrelation (Wooldridge, 2002), and found that there are indeed self-correlation problems in the data. In addition, we used the Modified Wald test to test the heterogeneity of the variance, and the results did find the problem of the heterogeneity of the variance. Finally, we tested the spatial dependence with Pesaran CD test and found that there is indeed a problem of spatial dependence. In the case of these three problems existing, both the Driscoll-Kraay estimation method and the feasible generalized least squares (FGLS) are reliable estimation methods. Since the Driscoll-Kraay estimation method is a special type of fixed effect model, Hoechle (2007) suggests that Hausman test can be used to distinguish which one should be used. The analysis results show that the individual effect exists, so we use the Driscoll-Kraay estimation method for analysis.

In the model for predicting R&D actions, we use the heterogeneous diffusion model (Strang and Tuma, 1993) for analysis. The heterogeneous diffusion model is a specific type of survival-time analysis. Since we control the influence of spatial dependence in the model for predicting R&D intensity, in order to make the two models more comparable, we control the two social proximity variables of industry and region in the heterogeneous diffusion model. In addition, the independent variables include the direct influence on adoption and the imitation possibility, and the characteristics of the two types of the focused firms. Thus, it is suitable to use the heterogeneous diffusion model for analysis.

3.3 Variables

This research divides the R&D investment decisions into two categories, namely whether to start R&D and how much investment should be made in R&D, which are operationalized into two dependent variables for research. Whether a manufacturer wants to conduct R&D is measured by adopting R&D, which means that a manufacturer decides whether to invest in R&D and decides to invest in R&D. We use the year of adoption to measure that year. When the manufacturer has not yet had R&D expenditure, it is 0, and when the manufacturer starts to have R&D expenditure, it is 1. R&D intensity reflects the amount of R&D investment by firm and is the most commonly used variable to measure the innovation input of manufacturers (Becheikh et al., 2006). The measurement formula is R&D expenditure divided by sales.

This research integrates the variables of previous studies on R&D investment decisions and divided them into four categories, namely, manufacturer resources, equity structure, business strategy, and risk-taking. It contains variables as follow. The first is the resources of firms, which includes internal and external resources. In terms of internal resources, past studies have pointed out that the larger the company, the more company resources, which is a good substitute for internal resources (Greve, 2003; Becheikh et al., 2006). Therefore, this study uses firm size as a substitute variable for internal resources, and its measurement method is the natural logarithm of the total number of employees. The number of employees is often used as a measure. Meanwhile, the greater the number of employees, the greater the firm's human resources. As for the external resources of the manufacturer, this study uses the debt-to-asset ratio as a variable. The higher the debt-to-asset ratio, the lower the financing ability and the higher the cost of borrowing. Thus, it is difficult to obtain external resources. We adopt the ratio of total liabilities to total assets as the measure.

The second is ownership structure. In addition to the common foreign equity ratios studied in the past, we have added two variables that are unique to China, one is the proportion of national capital and the other is the proportion of Taiwan, Hong Kong and Macao. This study measures the ratio of foreign equity to the amount of foreign capital and to the total amount of capital (Love et al., (1996), and uses the same measurement method to measure the proportion of national capital and the proportion of Taiwan, Hong Kong and Macao.

The third is business strategy. Business strategy is dichotomized into differentiated strategy and cost leadership strategy. Firms that implement differentiated strategies usually sell at higher prices than market and have higher gross profit (Berman, Wicks, Kotha, and Jones, 1999). At the same time, high investments will be made in product sales, marketing and impression management (Miller, 1987). Firms that follow cost leadership strategies attach great importance to efficiency (Hambrick, 1983). Specifically, manufacturers will strive to improve cost efficiency and capital simplicity and use the least assets and investment as much as possible to achieve sales goals. Accordingly, we refer to the measurement method of Balsam, Fernando, and Tripathy (2011), and use compound indicators to measure differentiation strategy and cost leadership strategy respectively. The differentiation strategy includes two indicators. One is the ratio of sales and administrative expenses (selling, general and administrative expenses) to turnover, which reflects the investment of manufacturers in sales and marketing activities, and establishes consumers' good products Impressions (Berman et al., 1999). The other is the ratio of turnover to the cost of goods sold, which reflects the characteristics of high price and high gross profit of the differentiation strategy (Berman et al., 1999). We add the two indicators as a measure of differentiation strategy. The cost leadership strategy also includes two indicators. One is the ratio of sales to the book value of plant and equipment, which represents the efficiency of asset use (Hambrick, 1983). The other is the ratio of the number of employees to total assets. This indicator was usually used to measure the efficiency of labor input (Hambrick, 1983). We also add the two indicators to measure the cost leadership strategy.

The fourth is risk-taking. The risk-taking variable is divided into surplus resources and performance expectations gaps. Among them, we use financial surplus as a measure of surplus resources. Because of its high discretion, financial surplus is considered to be the surplus resource that has the greatest impact on managers' decision-making (Moses, 1992). This research adopts the measurement of Mishina, Pollock, and Porac (2004). It is measured by working capital, that is, the difference between working capital and required working capital can be used. The specific calculation method is current assets minus current liabilities, and finally divided by 106 to avoid too small regression coefficient. Using working capital to measure financial surplus resources also reflects the short-

term use of financial resources by manufacturers (e.g. Mishina et al., 2004). When the financial surplus is positive, it means that the manufacturer has more financial resources than needed for operation. When it is negative, it means that the manufacturer has over-used resources in order to accelerate growth (Mishina et al., 2004). Past studies have pointed out that the gap in performance expectations can be divided into historical aspiration gaps and social aspiration gaps (Cyert and March, 1963). We use return on asset (ROA) to measure them separately (Chen and Miller, 2007; Gentry and Shen, 2013).

The historical performance expectation gap refers to the gap between the actual performance of the manufacturer and the past performance, which is measured by the current ROA minus the previous ROA. The social performance expectation gap refers to the gap between the average performance of the manufacturer and other peers, and the focus manufacturer's ROA minus the industry's average ROA To measure. Regardless of the historical performance expectations gap or the social performance expectations gap, when the value is positive, it means that the performance of the manufacturer is higher than its expected level. When it is negative, it means that the performance is lower than its expected level, and managers will be under greater pressure and try to achieve performance goals in various ways.

When studying the strategic actions of firms, the market position is an important control variable (Deephouse, 1999). This study uses market share as an operational measure of market position and calculates it as the main business turnover by the total industry turnover. In addition, it was mentioned earlier that Schumpeter (1934) pointed out that start-ups are the source of creativity, so we also control the age of the manufacturer. In addition, we also control regions and industries in the heterogeneous diffusion model. The regions are divided according to the administrative regions of the mainland, including 31 provinces and municipalities directly under the Central Government. Industries are classified according to the four-digit industry Standard Classification.

4. RESEARCH RESULTS

4.1 Descriptive Statistics

Table 1 is a descriptive statistics and correlation analysis. It can be seen from the table that although 32.7% of firms have invested in R&D, the overall average R&D intensity is still only 0.5%. This shows that the audio-video equipment industry needs to increase R&D and innovation energy. To encourage manufacturers to take R&D actions and to promote them to increase R&D intensity at the same time. The average age of the sample manufacturers is 7.9 years, the average asset-liability ratio is 53.8%, and the average foreign equity share is 17.6%. The average capital of Taiwan, Hong Kong, and Macau is also as high as 17.7%, but the average national capital is only 3.2%. The average market share of manufacturers is less than 0.3%, indicating that the information manufacturing industry in mainland China is very low-concentrated and is a highly competitive industry.

---Insert Table 1 about here---

For the table, the size of the manufacturer, differentiation strategy, and market share are significantly positively correlated with R&D intensity. In terms of the investment in R&D activities, there is a significant positive correlation with asset-liability ratio, scale, proportion of foreign capital, proportion of national capital, differentiation strategy, and market share, as well as cost leadership strategy, historical performance expectations gap, and the social performance expectation gap is significantly negatively correlated. However, both the firms with or without investment in R&D activities are included in the analysis, so they may be affected by the data without R&D activities, different from theoretical expectations. Therefore, more rigorous analysis is required to carry out. The correlation coefficients among other variables are all less than 0.7. Variables that are not highly correlated should not cause collinearity problems.

4.2 Driscoll-Kraay analysis

Table 2 shows the regression analysis results based on Driscoll-Kraay estimation. Mode 1 is the basic model and only contains control variables. Mode 2 adds resource variables. Mode 3 is the basic model plus equity structure variables. Mode 4 is the basic model plus categorical variables of business strategy. Mode 5 is the basic model plus risk-taking variables. Mode 6 is the integrated model. It can be seen from Mode 2 and Mode 6 that, among the resource variables, the asset-liability ratio has a significant positive impact on R&D intensity, which is contrary to theoretical expectations. The size of the manufacturer is different from expectations and has no significant impact. The results show that even if the higher the financing, the higher the R&D intensity of the manufacturer, but the larger the manufacturer may not make more R&D investment. In Mode 3 and Mode 6, we found that the proportion of foreign equity and the proportion of capital in Taiwan, Hong Kong and Macau have a significant positive impact on the R&D intensity. This result is the same as theoretical expectations. At the same time, the proportion of the state capital has a significant negative impact on R&D intensity, supporting the proposition that state-owned enterprises will reduce R&D investment due to lack of good governance and insufficient incentives. This result points out that in the information manufacturing industry in mainland China, whether it is the introduction of capital from Taiwan, Hong Kong, Macau or other foreign capital. It can promote the enhancement of manufacturers' R&D intensity.

---Insert Table 2 about here---

It can be seen from Mode 4 and Mode 6 that the two strategic variables have a significant impact on R&D investment, and both are in line with theoretical expectations. Differentiation strategy has a significant positive effect on R&D intensity; cost leadership strategy has a significant negative effect. In terms of risk-taking variables. Model 5 shows that financial margin has a significant negative impact on R&D intensity, which is different from theoretical expectations. Model 6 shows that the gap in social performance expectations has an impact. The intensity has a significant positive effect. The empirical results do not support the firm's behavior theory. When the performance of the manufacturer is higher than the average performance of the industry, managers will be willing to take greater risks and invest more in R&D. But when managers have more financial resources in their hands, on the contrary, it will reduce investment in research and development.

This study attempts to compare the relative effects of various variables on R&D intensity. In terms of explaining changes in the amount of variation, we found that the two strategy variables have the greatest increase in the ability to explain R&D intensity, followed by risk-taking Variables, and equity structure variables. The increase in resource variables has the smallest amount of explanatory variation. For the mode 6, in the integration model of all factors, except for financial margin, the significance of the impact of other variables remains unchanged, showing that various factors do have a significant impact on the intensity of R&D. In addition, two variables specific to the context of mainland China, the proportion of state capital and the proportion of capital in Taiwan, Hong Kong and Macao have also been found to have a significant impact on the intensity of R&D.

4.3 Analysis of Heterogeneous Diffusion Model

Table 4 shows the analysis results of the heterogeneous diffusion model. Mode 7 is the basic model which only includes the control input variables such as market share, age

of the firm, region and industry. Mode 8 is the basic model plus resource variables. Mode 9 is the basic model plus the equity structure variables. Mode 10 is a basic model plus strategy variables. Mode 11 is a basic model plus risk-taking variables. Mode 12 is an integrated model. In Mode 8 and Mode 12, only some of the resource variables have an impact on the R&D actions taken by the firms, and the size of the firms has a significant positive impact, which is in line with theoretical expectations. But the asset-liability ratio has no significant effect. The results show that the larger the firm, the more internal resources, the more likely the firm taking R&D actions. Mode 9 shows that among the equity structure variables, only the proportion of state capital has a positive and significant impact on R&D activities, but it is contrary to the negative effect of the proportion of state capital on R&D intensity Instead. It supports the positive proposition that state capital can increase manufacturers' R&D investment. In addition, neither foreign capital nor the proportion of capital from Taiwan, Hong Kong and Macao has a significant impact. In Mode 10 and Mode 12, the two strategic variables, differentiation strategy and cost leadership strategy, have no significant impact on the R&D actions taken by firms. In Mode 11 and Mode 12, we found that risk-taking factors have no significant impact on whether a firm takes R&D actions. Therefore, the research results failed to support the hypothesis of strategic and risk-taking variables in the R&D actions taken by firms. In addition, the card mode promoted by mode 10 and mode 11 is negative, which shows that the estimation of these two modes is not even as ideal as the basic mode.

---Insert Table 3 about here---

On the whole, research in the past found that most of the factors affecting R&D and innovation have no significant impact on the R&D actions taken by firms. Among them, the strategy and risk-taking elements have no impact on R&D actions. Among the other two types of variables, the resource element is better than the strategy element in terms of the effect of model estimation.

4.4 Model Comparison

We further compare the impact of ten forecast variables on R&D intensity and R&D actions. It is known now that the historical performance expectation gap has no significant impact on the R&D intensity and R&D actions, both of which are R&D investment decisions. Moreover, in the two models, no variable has the same impact, showing that taking R&D actions and the influencing factors of R&D intensity are completely different. The seven variables, asset-liability ratio, proportion of foreign equity, proportion of capital in Taiwan, Hong Kong and Macau, differentiation strategy, cost leadership strategy, financial surplus and historical performance expectations gap, only have an impact on R&D intensity, and cannot incentivize firms to take R&D actions . In addition, the size of the firm will only encourage firms to take R&D actions, but cannot increase the R&D intensity. The share of the capital presents different effects in the two models. The higher the proportion of national capital, although it will limit the R&D intensity of firms, it will make firms more willing to take R&D actions. This result can explain the conflicting results of the past research on R&D intensity only. State-owned enterprises are more likely to take R&D actions in order to comply with the public policies and have more resources, which has a positive impact on R&D investment. However, state-owned enterprises R&D investment is based on political considerations rather than economic considerations. In addition, there is no good governance mechanism and incentive system. Therefore, although state-owned enterprises will take R&D actions, their R&D intensity will be lower than that of other firm, which will have a negative impact on R&D investment Impact.

This result has several implications. First, the influencing factors of R&D intensity found in the past research can be mostly applied to the audio-visual equipment manufacturing industry in Mainland China. Second, R&D intensity and the influencing factors of taking R&D actions are completely different. Thus, the influencing factors of R&D intensity should not be used to predict whether a manufacturer will take R&D actions. Third, whether a manufacturer takes R&D actions and the intensity of investment in R&D are two different decisions. Factors may have completely different effects on the two decisions.

5. Concluding Remarks

This research aims to explore the factors that influence the R&D investment of mainland Chinese manufacturers, and try to clarify the four types of factors such as resource endowment, equity structure, business strategy, and risk-taking can simultaneously promote R&D and increase the intensity of R&D in a transitional economy like China. The main findings are summarized in the following. Firstly, R&D intensity in mature economies such as Europe and the US can be partly applicable to the context of a transitional economy in China. Secondly, taking R&D actions and the factors affecting R&D intensity are completely different. Variables are still to be explored. Thirdly, using the proportion of national capital to encourage firms to invest in R&D may have both positive and negative effects. On the one hand, it can positively promote firms to take R&D behaviors. On the other hand, they can negatively weaken the R&D intensity. Based on the above findings, this research has the following contributions to academic and practical aspects.

First of all, among the ten influencing factors tested in this study, six factors have the same impact on R&D intensity as theoretically expected. Two factors, including the gap between the firm's scale and historical performance expectations, have no significant impact on R&D intensity. The impact of the gap between the asset-liability ratio and historical performance expectations is contrary to theoretical expectations. On the whole, research on mature economies such as Europe and the US still has something to learn from China, especially in terms of equity structure and strategy variables. However, a small number of variables are not suitable for China, especially resource elements, which do not support Western theories at all. Among the three variables of risk-taking, only the impact of the gap in social performance expectations on R&D intensity meets theoretical expectations. This result may be due to the financing difficulties of Chinese firms and the lack of R&D resources. Even if the manufacturers have more resources, they may not invest in R&D activities.

In addition, due to the cultural differences between the East and the West, the factors that affect managers' risk-taking may be different, and the impact of risk-taking factors may not meet theoretical expectations. Secondly, in predicting whether a firm will take R&D actions, only two of the ten factors tested have a significant impact, namely the size of the firm and the proportion of state-owned capital. This result shows that the R&D actions taken by manufacturers and the influencing factors of R&D intensity may be completely different. In the past, studies have mostly emphasized how to promote R&D expenditure and R&D intensity of manufacturers. However, we know little about why manufacturers are willing to take R&D actions or why they never take R&D actions. The preliminary results of this research show that Chinese firms do not take R&D actions based on strategic and risk-taking consideration. Only some of the resources and equity structure variables can prompt firm to take R&D actions. Future research can further explore other possible influence factors.

Furthermore, this study found that the investment of state-owned capital does have a positive and negative impact on the R&D investment at the same time. Specifically, state-owned capital will encourage firms to follow public policies

and then take R&D actions; however, the lack of good corporate governance mechanisms and incentives will cause firms to reduce the intensity of R&D. This finding explains on the one hand the opinions and empirical results of state-owned capital on the positive and negative poles of research investment in the past literature. On the other hand, it also shows that some factors may have the opposite effect on the R&D actions taken by firms and the R&D intensity. If policy makers formulate policies based only on the influencing factors to increase the intensity of R&D in order to increase the country's R&D capacity, they may ignore that these influencing factors will inhibit firms that have not yet invested in R&D and take R&D actions, which will ultimately make the policy effective lower as expected.

Table 1. Descriptive statistics and correlation analysis

	1		2		3		4		5		6		7		8		9		10		11		12		13		Mean	SD
R&D behaviors	1.00																										0.327	0.276
R&D intensity	0.42	***	1.00																								0.005	0.021
Asset-liability ratio	0.09	***	0.13		1.00																						0.538	0.325
Firm's scale	0.44	***	0.22	***	0.36	**	1.00																				4.998	2.001
Foreign equity ratios	0.11	***	0.14		-0.33	***	0.26	***	1.00																		0.176	0.272
National capital ratio	0.11	**	0.12		0.17	***	0.19	***	-0.12		1.00																0.032	0.221
Taiwan, Hong Kong and Macao Capital ratio	-0.08		-0.28		-0.19	***	0.32	***	-0.28	***	-0.24		1.00														0.17	0.237
Differentiated strategy	0.12	**	0.19	***	-0.21	***	0.21		0.11	***	0.14		0.21		1.00												1.563	0.124
Cost leadership strategy	-0.04	*	0.03		-0.31	***	-0.30		-0.11		-0.27	***	0.09		0.13	***	1.00										2.111	0.118
Financial surplus	0.06		-0.05		-0.28	***	-0.24		0.16	**	-0.21	***	0.34		0.11		0.16	***	1.00								0.006	0.138
Historical performance expectation gap	-0.09	*	-0.07		0.03		-0.16		-0.41		0.10		0.21		0.21		0.33	***	0.10		1.00						-0.028	0.281
Social performance expectation gap	-0.11	**	-0.11		-0.10	***	-0.41	*	-0.23		-0.19	***	-0.37	***	0.15	*	0.48	***	0.21	***	0.41		1.00				-0.031	0.226
Market share	0.21	***	0.11	***	0.11		0.40	***	0.35	***	0.13	*	-0.12		0.34		-0.22		-0.06	***	-0.11		-0.23		1.00		0.003	0.011
Firm's age	0.06		0.10		-0.16	**	0.25	***	-0.12		0.22	***	0.16		0.22	***	-0.18	***	-0.22		0.09		-0.29	***	0.17	***	7.863	5.376

Note: "***", "**", and "*" denote statistical significance at 1%, 5%, and 10% level, respectively.

Table 2. Panel data regression analysis

	Mode 1		Mode 2		Mode 3		Mode 4		Mode 5		Mode 6	
Debt-asset ratio			0.02112	**							0.0200	**
			(0.0109)								(0.0105)	
Firm's scale			-0.0020								-0.0012	
			(1.9800)								(0.0022)	
Foreign equity ratios					0.00131	***					0.031	***
					(0.00033)						(0.011)	
National capital ratio					-0.0202	*					-0.0080	*
					(0.0112)						(0.0044)	
THM Capital ratio					0.0200	***					0.00221	***
					(0.0037)						(0.00068)	
Differentiated strategy							0.0310	***			0.0500	***
							(0.0011)				(0.0187)	
Cost leadership strategy							-0.081	***			-0.051	*
							(0.0177)				(0.021)	
Financial surplus									-0.0220	***	0.0022	
									(0.0028)		(0.0018)	
HPE gap									-0.0130		-0.0220	
									(0.0082)		(0.028)	
SPE gap									-0.0330		0.0480	***
									(0.0236)		(0.013)	
Market share	-0.029	*	-0.032		1.32	*	0.73	**	0.88	***	0.72	**
	(0.016)		(0.223)		(0.78)		(0.39)		(0.34)		(0.38)	
Firm's age	0.00013		0.00011		0.00199	*	0.00020		0.00035	*	0.0023	
	0.00216		0.00048		0.00115		0.00016		0.00021		0.0017	
Constant	0.00101		0.0055		0.0022		0.662	***	0.0033		0.067	*
	(0.00077)		0.0086		(0.0029)		(0.196)		(0.0022)		(0.038)	

Adjusted R^2	0.030		0.025		0.030		0.061		0.012		0.163	
F-statistics	0.386		9.086	***	73.166	***	92.870	***	9.856	***	23.680	***

Note: The table is made at two digit significance. Figures in the parentheses are standard errors. "***", "**", and "*" denote statistical significance at 1%, 5%, and 10% level, respectively. "THM" denotes "Taiwan, Hong Kong and Macao". "HPE" denotes "Historical performance expectation". "SPE" denotes "Social performance expectation".

Table 3. Heterogeneous diffusion model regression analysis

	Mode 7		Mode 8		Mode 9		Mode 10		Mode 11		Mode 12	
Debt-asset ratio			0.23								0.077	
			(0.68)								(0.344)	
Firm's scale			0.370	***							0.493	***
			(0.091)								(0.218)	
Foreign equity ratios					0.41						-0.54	
					(0.39)						(0.81)	
National capital ratio					2.18	*					2.060	
					(1.28)						(1.954)	
THM Capital ratio					0.21						0.63	
					(0.44)						(0.48)	
Differentiated strategy							0.55				1.11	
							(0.44)				(1.02)	
Cost leadership strategy							-1.66				-2.170	
							(1.99)				(3.092)	
Financial surplus									-0.0110		0.0190	*
									(0.054)		(0.0098)	
HPE gap									0.0021		0.0030	
									(0.0038)		(0.0061)	
SPE gap									-0.0098		-0.0060	
									(0.0084)		(0.1100)	
Market share	73.81	***	2.228		77.78	***	24.73	***	28.18	***	9.98	
	(17.28)		(3.416)		(14.39)		(11.93)		(12.22)		(8.22)	
Firm's age	0.081		0.0032		-0.0040		0.0031		0.0070		0.012	
	(0.123)		(0.0028)		(0.0065)		(0.0053)		(0.0065)		(0.084)	
Constant	-3.31	***	-2.91	***	-2.38	***	-4.27		-3.35	***	-3.33	*
	(0.55)		(1.26)		(1.12)		(2.65)		(1.11)		(1.99)	
χ 2-statistics	32.49	***	88.75	***	76.88	***	38.28	***	43.21	***	118.32	***

Note: The table is made at two digit significance. Figures in the parentheses are standard errors. "***", "**", and "*" denote statistical significance at 1%, 5%, and 10% level, respectively. "THM" denotes "Taiwan, Hong Kong and Macao". "HPE" denotes "Historical performance expectation". "SPE" denotes "Social performance expectation".

6. REFERENCES

1. Anwar, S., and Sun, S. (2013) "Foreign Entry and Firm R&D: Evidence from Chinese Manufacturing Industries," *R&D Management*, 43, 303–317.
2. Asheim, B.T., and Isaksen, A. (1997) "Location, Agglomeration and Innovation: Towards Regional Innovation Systems in Norway," *European Planning Studies*, 5, 299–330.
3. Balsam, S., Fernando, G.D., and Tripathy, A. (2011) "The Impact of Firm Strategy on Performance Measures Used in Executive Compensation," *Journal of Business Research*, 64, 187-193.
4. Becheikh, N., Landry, R., and Amara, N. (2006) "Lessons from Innovation Empirical Studies in the Manufacturing Sector: A Systematic Review of the Literature from 1993-2003," *Technovation*, 26, 644-664.
5. Beneito, P. (2003) "Choosing among Alternative Technological Strategies: An Empirical Analysis of Formal Sources of Innovation," *Research Policy*, 32, 693–713.
6. Berman, S.L., Wicks, A.C., Kotha, S., and Jones, T.M. (1999) "Does Stakeholder Orientation Matter? The Relationship between Stakeholder Management Models," *Academy of Management Journal*, 42, 488–506.
7. Bishop, P., and Wiseman, N. (1999) "External Ownership and Innovation in the United Kingdom," *Applied Economics*, 31, 443–450.
8. Bourgeois, L.J. (1981) "On the Measurement of Organizational Slack", *Academy of Management Review*, 6, 29–39.
9. Brown, S.L., and Eisenhardt, K.M. (1995) "Product Development: Past Research, Present Findings, and Future Direction," *Academy of Management Review*, 20, 343–378.
10. Cai, H., and Liu, Q. (2009) "Competition and Corporate Tax Avoidance: Evidence from Chinese Industrial Firms," *Economic Journal*, 119, 764-795.
11. Chang, S.J., Chung, C., and Mahmood, I.P. (2006) "When and How Does Business Group Affiliation Promote Firm Innovation? A Tale of Two Emerging Economies," *Organization Science*, 17, 637–656.
12. Chou, C. (2007) "The Mainland China Reform of Science and Technology System and Its Influence on the Technologic Development of Information Industry: 1980-2000," *Journal of China Institute of Technology*, 36, 515-532.
13. Chen, W.R., and Miller, K. (2007) "Situational and Institutional Determinants of Firms' R&D Search Intensity," *Strategic Management Journal*, 28, 369-381.
14. Chen, Z.C. and Yu, X. (2007) "A Study on Impact of External Environment on R&D Input of Enterprises: Empirical Analysis on Panel Data of Chinese Industries," *Science Research Management*, 28, 78-84.
15. Choi, J.J., Lam, K.C.K., Sami, H., and Zhou, H. (2013) "Foreign Ownership and Information Asymmetry," *Asia-Pacific Journal of Financial Studies*, 42, 141–166.
16. Choi, S.B., Lee, S. H., and Williams, C. (2011) "Ownership and Firm Innovation in A Transition Economy: Evidence from China," *Research Policy*, 40, 441–452.
17. Cohen, W.M., and Levinthal, D.A. (1990) "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, 35, 128–152
18. Cuervo-Cazurra, A., and Un, C.A. (2010) "Why Some Firms Never Invest in Formal R&D," *Strategic Management Journal*, 31, 759–779.
19. Cyert, R.M., and March, J.G. (1963) *A Behavioral Theory of the Firm*. New Jersey: Prentice-Hall.
20. De Propris, L. (2000) "Innovation and Inter-Firm Co-Operation: The Case of the West Midlands," *Economics of Innovation and New Technology*, 9, 421–446.
21. Deephouse, D.L. (1999) "To Be Different, or to Be the Same? It's a Question (and Theory) of Strategic Balance," *Strategic Management Journal*, 20, 147-166.
22. Dobson, W., and Safarian, A.E. (2008) "The Transition from Imitation to Innovation: An Enquiry into China's 31 Evolving Institutions and Firm Capabilities," *Journal of Asian Economics*, 19, 301–311.
23. Galende J., and Su´arez I. (1999) "A Resource-Based Analysis of the Factors Determining a Firm's R&D Activities," *Research Policy*, 28, 891–905.
24. Gao, Y., and Hafsi, T. (2015) "R&D Spending among Chinese SMEs: The Role of Business Owners' Characteristics," *Management Decision*, 53, 1714-1735.
25. Gentry, R.J., and Shen, W. (2013) "The Impacts of Performance Relative to Analyst Forecasts and Analyst Coverage on Firm R&D Intensity," *Strategic Management Journal*, 34, 121-130.
26. Giudici, G., and Paleari, S. (2000) "The Provision of Finance to Innovation: A Survey Conducted among Italian Technology-Based Small Firms," *Small Business Economics*, 14, 37–53.
27. Greve, H.R. (1998) "Performance, Aspirations, and Risky Organizational Change," *Administrative Science Quarterly*, 43, 58–86.
28. Greve, H.R. (2003) "A Behavioral Theory of R&D Expenditures and Innovations: Evidence from Shipbuilding," *Academy of Management Journal*, 46, 685–702.
29. Guzzini, E., and Iacobucci, D. (2014) "Ownership as R&D Incentive in Business Groups," *Small Business Economics*, 43, 119–135.
30. Hambrick, D.C. (1983) "Some Tests of The Effectiveness and Functional Attributes of Miles and Snow's Strategic Types," *Academy of Management Journal*, 26, 5-26.
31. Hoechle, D. (2007) "Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence", *Stata Journal*, **7**, 281–298.
32. Hofstede, G. (1991) *Culture's consequences*, Beverly Hills, California: Sage.
33. Hu, A.G., and Jefferson, G. (2009) "A Great Wall of Parents: What is Behind China's Recent Patent Explosion?" *Journal of Development Economics*, 90, 57-68.
34. Ju, M., and Zhao, H. (2009) "Behind Organizational Slack and Firm Performance in China: The Moderating Roles of Ownership and Competitive

Intensity," *Asia Pacific Journal of Management*, 26, 701-717.
35. Lee, J.F. and Kao, H.H. (2011) "The Shanzhai Way of Innovation: Responsive, Staying Lean, and Flexible - The Case of Shanzhai Mobile Phone Players in China," *Sun Yat Sen Management Review*, 19, 547~586.
36. Levinthal, D.A., and March, J.G. (1981) "A Model of Adaptive Organizational Slack," *Journal of Economic Behavior and Organization*, 2, 307-333.
37. Lieberman M.B., and Asaba, S. (2006) "Why Do Firms Imitate Each Other?" *Academy of Management Review*, 31, 366–385.
38. Lim, E.N.K. (2015) "The Role of Reference Point in CEO Restricted Stock and Its Impact on R&D Intensity in High-Technology Firms," *Strategic Management Journal*, 36, 872-889.
39. Love, J.H., Ashcroft, B., and Dunlop, S. (1996) "Corporate Structure, Ownership and the Likelihood of Innovation", *Applied Economics*, 28, 737–746.
40. Lu, L.Y.Y. and Liu, J.S. (2004) "R&D in China: An Empirical Study of Taiwanese IT Companies," *R&D Management*, 34, 453–465.
41. Michie, J. (1998) "Introduction. The Internationalisation of the Innovation Process," *International Journal of the Economics of Business*, 5, 261–277.
42. Miller, D. (1987) "The Structural and Environmental Correlates of Business Strategy," *Strategic Management Journal*, 8, 55–76.
43. Minagawa, T., Trott, P., and Hoecht, A. (2007) "Counterfeit, Imitation, Reverse Engineering and Learning: Reflections from Chinese Manufacturing Firms," *R&D Management*, 37, 455–467.
44. Mishina, Y., Pollock, T., and Porac, J. (2004) "Are More Resources Always Better for Growth? Resource Stickiness in Market and Product Expansion," *Strategic Management Journal*, 25, 1179–1197.
45. Moses, D.O. (1992) "Organizational Slack and Risk-Taking Behavior: Tests of Product Pricing Strategy," *Journal of Organizational Change Management*, 5, 38-54.
46. Penrose, E.T. (1959) *The Theory of the Growth of the Firm*. New York: John Wiley & Sons.
47. Porter, M.E. (1980) *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, New York: Free Press.
48. Rothwell, R. (1992) "Successful Industrial Innovation: Critical Factors for the 1990s", *R&D Management*, 22, 221–239.
49. Rodriguez, M. (2013) "Knowledge-Intensive Business Services and R&D Diffusion: A Comparative Assessment of Some EU27 Countries", *Engineering Economics*, 24, 300–308.
50. Schneiberg, M., and Clemens, E. S. (2006) "The Typical Tools for the Job: Research Strategies in Institutional Analysis," *Sociological Theory*, 24, 195–227.
51. Schumpeter, J.A. (1934) *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.
52. Schumpeter, J.A. (1942) *Capitalism, Socialism and Democracy*. New York: Harper.
53. Sciascia, S., Nordqvist, M., Mazzola, P., and De Massis, A. (2015) "Family Ownership and R&D Intensity in Small- and Medium-Sized Firms", *Journal of Product Innovation Management*, 32, 349–360.
54. Sun, W.F. (2015) "Financial Constraints and R&D Expenditure: Empirical Study based on Chinese Manufacturing Listing Corporation" *Journal of Lanzhou University of Finance and Economics*, 4, 87-94.
55. Stock, G.N., Greis, N.P., and Fischer, W.A. (2002) "Firm Size and Dynamic Technological Innovation," *Technovation*, 2, 537–549.
56. Strang, D., and Tuma, N. B. (1993) "Spatial and Temporal Heterogeneity in Diffusion", *American Journal of Sociology*, 99, 614–639.
57. Tan, J., and Peng, M. W. (2003) "Organizational Slack and Firm Performance during Economic Transitions: Two Studies from an Emerging Economy", *Strategic Management Journal*, 24, 1249-1263.
58. Tavassoli, S. (2015) "Innovation Determinants over Industry Life Cycle," Technological Forecasting and Social Change, 91, 18-32.
59. Tsai, W. (2001) "Knowledge Transfer in Intraorganizational Networks: Effects of Network Position and Absorptive Capacity on Business Unit Innovation and Performance," *Academy of Management Journal*, 44, 996–1004.
60. Wang, X, R. and Bu, W. (2008) "Study on R&D Factors in Enterprises both at Home and Abroad," *China Management Informationization*, 11, 92-94.
61. Wooldridge, J. (2002), *Econometric Analysis of Cross-Section and Panel Data*. Cambridge, MA: MIT Press.
62. Xie, W., and White, S. (2006) "From Imitation to Creation: The Critical Yet Uncertain Transition for Chinese Firms," *Journal of Technology Management*, 1, 229–242.
63. Zahra, S.A. (1993), "New Product Innovation In Established Companies: Associations with Industry and Strategy Variables," *Entrepreneurship Theory and Practice*, 18, 47–69.
64. Zhou, Y. (2014) "Role of Institutional Quality in Determining the R&D Investment of Chinese Firms," *China and World Economy*, 22, 60-82.
65. Zhu, Y., Wittmann, X., and Peng, M. (2011) "Institution-Based Barriers to Innovation in SMEs in China," *Asia Pacific Journal of Management*, 29, 1131-1142.