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Research Article

Research on Chinese Enterprise Technological Innovation and Product Competitiveness

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Abstract: This study aims to investigate the influence of product competitiveness on the technological innovation in Chinese enterprises. The investigation starts from micro-level enterprises and the samples comes from the non-financial sectors of Shanghai and Shenzhen listed companies during 2002-2012. Novel simultaneous equations have been established based on the Hausman simultaneous test analysis to examine whether there is endogenous between innovation and competition and also test the bidirectional relationship of product market competition and enterprise innovation. The analysis results show that excessive competition would dampen the enthusiasm of innovation and influence the improvement of enterprise technological innovation. Excessive monopoly makes the companies generate a scene of complacency and reduces technological innovation. Therefore, there exists U-shipped relationship between product competition and enterprise technological innovation. In addition, variables about enterprise characteristics and governance also show influence on the technological innovation. Based on the above conclusions, some recommendations have been proposed to improve the technological innovation of Chinese listed companies.

Keywords: Chinese listed companies, product-market competition, technological innovation

INTRODUCTION

More than 30 years since China's reform and opening-up, China's economy has experienced high-speed development. The society is at its transformation phase. The economy structure and the industry are urgent for upgrade, for which self-innovation will be the core impulse (Romer, 1986; Lucas, 1988). With macro aspects of the economic, technology is the main motivation of economy development (Cooper, 1976). From the micro aspects, technological innovation has become the key source of competitiveness improvement and competition advantage. Since Joseph Schumpeter proposed the innovation theory, scholars have undertaken many researches about the factors that may affect the enterprise technological innovation. The fiercest domain is the relationship of innovation and competition and they have not reached a unanimous conclusion. Then, in China, how does product-market competition affect the enterprise technological innovation? Though Chinese scholars have done researches about this question, the researchers can not completely describe the influence, for the lack of data and single-faceted research about the industry but not micro companies.

For this reason, this study is indented to take advantage of the sample of Shanghai and Shenzhen listed companies during 2002-2010 and analyze the relation of product-market enterprise technological innovation through regression analysis. During the research, Herfindahl-Hirschman Index (HHI) is used to measure product-market competition and the strength of Research and Development (R&D) is used to measure technological innovation. This study will enrich the research of Chinese listed companies' market structure and technological innovation and propose some political suggestions to reform marketing competition environment for the sick of technological innovation development. Compared with existing researches, this study shows the following notable characteristics:

- Data from micro listed companies
- Large amount of samples
- Wide ranges of industries
- Enterprise governance variables are introduced as control variables for empirical analysis

LITERATURE REVIEW

Since Schumpeter (1942) put forward innovation theory, the relation between competition and innovation has attracted much attention and scholars from many countries conduct large amount of theoretical analysis and empirical test. But until now, no consistent conclusion is gained. The existing researches can be

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divided into three parts according to the conclusions: firstly, monopoly is in favor of innovation (there is a negative correlation between competition and innovation); secondly, perfect competition is beneficial to innovation (there is a positive correlation between competition and innovation); thirdly, moderate competition is helpful to innovation (there is an inverse U shape between innovation and competition). Theoretically, Schumpeter believes that monopoly is good to innovation, as in monopoly market, enterprises can gain more from innovation. Gilbert and Newbery (1982) built a patent competition model, to state that monopoly enterprises gain more motivation to do technological innovation than ordinary enterprises. Arrow (1962) compared the potential incomes under the market structure of monopoly and competitive and discovered that enterprises in competitive market get more from technological innovation than that in monopoly market, so he came to the conclusion that completely competition is in favor of innovation. Scherer (1980) considered that monopoly will impulse the laziness of the managers and make them unwilling to conduct technological innovation. While the increased competition will reduce the shirking behaviors and motivate the managers to improve technological innovation, lower the costs and increase the profits. Poter (1990) indicated that fierce competition will compel the companies to implement innovation for the purpose of survival, which will also improve the development of economy. Densetz (1969) improved the assumption of Arrow model and proves that the inverse U shape is existed. The market that between completely competition and completely monopoly is best for innovation. On one hand, excessive competition would dampen the enthusiasm of innovation; on the other hand, excessive monopoly makes the companies generate a scene of complacency and reduce technological innovation (Densetz, 1969).

For empirical analysis, scholars from different countries also get different results. Howrowitz (1962) is one of the earliest researchers of this domain. He collected America industry data and took advantage of C4 to measure market concentration. The analysis results showed that there is a positive correlation between market concentration and the strength of R&D investment. Kraft (1989) analyzed the data of West Germany companies and fond that the increase of market concentration will improve the level of technological innovation. Blundell *et al*. (1995) disposed the panel data from English manufacturing companies during 1972-1982 and found that the influence of market concentration to the amount of innovation is positive and monopoly companies get more chance to conduct innovation. Geroski (1990) hold the opinion that compared with highly concentration industry, competitive industries are more beneficial to enterprise technological innovation and monopoly powers hinder the innovation. Nick (1996) and Carlin *et al*. (2004) used empirical analysis to prove that the relation between competitive and innovation is positive and the improving of competition will encourage innovation. Different from the conclusions above, Scherer (1967) found that a reverse U shape is existed when describe the relation of competition and innovation. Aghion *et al*. (2005) believed that when the level of competition is low, the positive effect of competitive to R&D is dominant; when the level of competition increase to a certain point, the negative effect takes over, so the curve is reverse U shape. The conclusion is been tested by the empirical data from 330 companies from England. Moreover, reversed U shape of competition and innovation has been found in England, Sweden and France (Tingvall and Poldahl, 2006; Tingvall and Karpaty, 2011).

In China, early researches are about the introduction of theories and literature reviews. Liu and Wan (1997) divides 16industries into two groups according to the concentration and then analyzes the average technology development funds of each worker. He finds that industries with high concentration invest more in technology development Schumpeter (1942). Xu (2006) makes use of China's industries section data and the empirical analysis finds that competition and profits got from monopoly are both in favor of technological innovation. Ping and Zhou (2007) analyzed the influence of market competition to R&D, which is based on the data of Chinese manufacturing companies for 5 years. In their research, market competition is measured by proportion of private enterprise and average profit rate of industry and a reversed U shape appears when analyzing the relationship of market competition. Chen *et al*. (2007) take advantage of Lerner Index to measure the industry concentration and R&D funding to measure innovation of technology and find that the industry market competition shows an inverted U-shaped relationship with innovation. Sun and Tian (2010) applied the data of 37 china's industrial segments data of 2006, to analyze the relationship of competition and innovation with the support of simultaneous equations. The results suggest that competition is in favor of technological innovation, while the improvement of innovation aggravates market competition.

According to the empirical analysis, early researches are data about macro R&D investment and recently, the research approaches have turned to micro companies. But the data are from manufacturing

industry and the innovation research about micro companies is weak; there is no research focused on technological innovation about listed companies. Listed companies are representation of Chinese companies and researches about their innovation behaviors are of great significance. The measurement of variables about micro researches is problematic. In many industries, the process of patent application would be longer than the period of investment return and enterprises may implement innovation but do not apply for patents. So the measurement of technological innovation with patents is a problem to be discussed. For the measurement of market competition, Herfindahl index seems to be the best, when internal market is the main market (Tingvall and Karpaty, 2011). For this reason, this study takes advantage of R&D investment to measure technological innovation and HHI to measure market competition; analyzes the influence of product market competition to enterprise technological innovation on account of data from Shanghai and Shenzhen non financial industries listed- companies during 2002-2010.

ANALYSIS MODEL

Variables setting

- **Explained variables:** The explained variables of this study are the enterprise technological innovation (R&D), referencing to Balkin and Markman (2000), which is measured by the ratio of R&D investment and main business income
- **Explanatory variables:** The explanatory variable is product market competition. According to industrial organization theory, how to define market is a problem, so there is no accepted appropriate index to accurately measure product market competition. It is believed that HHI seems to be a very effective index when internal market is the main market. So HHI is chosen to represent product market competition. On the basis of listed companies information got from Peking University academic financial database, HHI indexes of each industry are calculated. The lower the index is, the more intense the competition is
- **Control variables:** The control variables of this study is consist of enterprise characteristic variables and enterprise governance variables
- **Enterprise characteristic variables:**
  Size: the natural logarithm of total assets of the companies works as substitution variable of enterprise scale. High investment is needed for technological innovation and high risk is always coming along. Large corporations occupy more resource and can meet the demand of high investment. On the other hand, companies with large scale can invest to different domains and technical risk can be scattered through diversification of investment. Dai and Da (2007) proposed that the larger the enterprise is, the higher the R&D investment is.

Leverage: It is measured by the ratio of total liabilities and total asserts. When the liabilities of the enterprise are high, it faces higher risk of bankruptcy and creditors unwilling to bear the high risk to support the R&D. Nam *et al*. (2003) also found that the R&D is lower in company with high debts.

Growth: The opportunity to grow is a critical motivation of enterprise investment. The higher the growth of the company, the greater the motivation is to take advantage of technological innovation to create growth opportunities.

- **Enterprise governance variables:**
  CR5: it is measured by sum of Shareholding percentage of top 5 shareholders. Concentrated shareholdings can increase the supervisory-control capability of shareholders and reduce "free rider" behaviors by supervising the innovation behaviors of managers. For China's private enterprises, the entrepreneurs are always the first shareholders and the more shareholdings he get, the more innovation activities will be implement to make the long run subjects come true. Lee and O'Neil (2003) thought that large shareholders are more intended to acquire high and long-term returns through increasing innovation investment. The results of empirical analysis propose that the concentration of ownership is positively related to technological innovation investment.

Outside: is presented by the ratio of the number of independent directors with the total number on board. Independent directors can supervise the management layer, effectively compensate for the absence of supervisor and prevent the short-sight behavior of management layer. They can also work for the long-term development of the enterprise and positively improve the technological innovation. Chung *et al*. (2003) find that the ratio of independent directors is positively connected to the investment of technological innovation.

State: is a dummy variable, if the type of final controller is state-owned, 1 and 0 otherwise. It is 1 if

the enterprise chairman and general manager are served by one person and 0 otherwise.

MHS: the proportion of executives' shareholdings. Shareholding motivation will increase the sense of belonging and connect the benefits of executives with the enterprise, which is beneficial to technological innovation. Wu and Tu (2007) also suggested that the ratio of CEO shareholdings positively may influence the R&D of enterprise.

Econometric model: Industrial organization theory suggest that, the product market competition and enterprise innovation may be a bidirectional relationship, namely, the competition influences the innovation and instead the same. Dasgupta and Stilitz (1980) recommend that not only market competition affects the innovation, the innovation also affect the forming of market structures. For the purpose of avoiding possible errors, this study build simultaneous equations to examine whether there is endogenous between innovation and competition and also test the bidirectional relationship of product market competition and enterprise innovation by Hausman simultaneous test. Simultaneous equations are as follow:

$$R\&D = \lambda_0 + \lambda_1 HHI + \lambda_2 R\&D(-1) + \lambda \sum CONTROL + \sum YEAR + \sum INDUSTRY + \varepsilon \quad (1)$$

$$HHI = \eta_0 + \eta_1 R\&D + \eta_2 HHI(-1) + \eta \sum CONTROL + \sum YEAR + \sum INDUSTRY + \varepsilon \quad (2)$$

R&D is enterprise technological innovation, HHI Herfindahi index and control a series control variables. Regression is made on the base of above equations (limited by this study, specific results are not listed). The regression results suggest that the coefficient of innovation and competition is not significant. Hauaman simultaneous test also reveal that there is no bidirectional relationship between product market competition and enterprise innovation among China's listed companies.

Existed researches indicate that monotonic or secondary linear relationships are possibly presence between product market competition and enterprise innovation. In order to completely investigate the influence, the following model is applied:

$$R\&D = \alpha_0 + \beta_1 HHI + \beta_2 HHI^2 + \beta_3 SIZE + \beta_4 LEVERAGE + \beta_5 GROWTH + \beta_6 SHARE + \beta_7 OUTSIDE + \beta_8 STATE + \beta_9 MHS + \sum INDUSTRY + \sum YEAR + \varepsilon \quad (3)$$

Sample selection and data sources: The object of the study is the listed companies of shanghai and Shenzhen during 2002-2010, experienced the following selection:

- Excluding the listed companies do not disclose R&D investment
- Excluding financial listed companies, for its financial criteria is different from other industries
- Excluding companies with missing data and data anomalies.

After selection, 1268 observations are left. R&D data is got from www.cninfo.com.cn, which is specified by China Securities Regulatory Commission to disclose information. The information includes the prepaid expenses, long-term prepaid expenses, accrued expenses, cash flow from operating activities and management fee. This study collects the data about R&D investment from the above disclosed information, the general styles are technology development costs, research and development expenses, R&D fee, R&D project costs, technology fee, research and development fee, development fee, new product development costs, science and technology research expense, new product testing and development expenses and research and investigation fee.

EMPIRICAL RESEARCH

Descriptive statistics: Table 1 lists the descriptive characteristics of each variables. The average R&D is 0.025, which manifest that the percentage of technological innovation investment is 2.5% about the total income and it is less compared with other countries. The biggest R&D of the sample company is 0.57 and the minimum 0.0001. While the difference about technological innovation of each company is not so big, the standard error is 0.057. The average product market competition measured by HHI is about 0.069, which means the competition of listed companies is fierce. Among the enterprise characteristic variables, the average size is 21.277, with maximum 26.099 and minimum 17.484. The average liabilities of the sample companies is above half of the total capital, about 51.4%, with the lowest 0 and the highest about 43.075 times about the total capital. The average Tobin's q ratio is about 1.752 and standard error 1.463, the biggest of all the standard errors, which suggests that

Table 1: 1997-2007 China service industry manufacturization level table

Variables	Average	Min	Median	Max	S.E.
R&D	0.025	0.00001	0.006	0.570	0.0565
HHI	0.069	0.018	0.040	0.878	0.083
Size	21.277	17.484	21.185	26.099	1.037
Lev	0.514	0.000	0.469	43.075	0.888
Growth	1.752	0.548	1.358	25.167	1.436
Outside	0.557	0.000	0.5	1.0	0.160
MHS	0.046	0.000	0.000	0.980	0.137
State	0.56	0	1	1	0.496
Share	0.555	0.053	0.568	1.000	0.158

Table 2: The person correlation coefficient of each variable

	R&D	HHI	Size	Lev	Growth	Outside	MHS	State
HHI	0.017							
Size	0.257	0.044						
Lev	0.024	0.002	0.066					
Growth	0.086	0.000	0.155	0.149				
Outside	0.073	0.017	0.019	0.025	0.079			
MHS	0.128	0.047	0.207	0.062	0.015	0.129		
State	0.222	0.023	0.262	0.008	0.077	0.158	0.261	
Share	0.046	0.071	0.010	0.060	0.109	0.050	0.184	0.034

Table 3: The regression results about the influence of product market competition on innovation

Variables	Model 1	Model 2	Model 3
Constant	0.019	0.305	0.251
	(11.066)	(14.933)	(11.793)
HHI	0.116	0.110	0.089
	(4.437)	(4.382)	(3.565)
HHI^2	-0.167	-0.147	-0.114
	(-4.505)	(-4.090)	(-3.207)
Size		-0.014	-0.01
		(-14.241)	(-11.512)
Lev		-7.30E-005	0.000
		(-0.066)	(0.214)
Growth		0.001	0.001
		(2.751)	(2.526)
Outside			0.014
			(2.335)
MHS			0.006
			(1.807)
State			-0.017
			(-7.843)
Share			0.015
			(2.415)
Year		Control	Control
Industry		Control	Control
R square	0.007	0.074	0.101
Adj R square	0.006	0.072	0.098

the difference of Tobin's q ratio among Chinese listed companies is huge. About the enterprise governance variables, independent director ratio is about 0.557, which reveals that independent directors have composed more than half of the board. Among the sample companies, the ratio of executives' shareholdings is about 0.046, which is not high and the option incentive is low. State-owned enterprise make up for 56% of the sample companies. The average CR5is about 0.555, revealing that the top 5 shareholders get more than half about shareholdings.

Correlation analysis: Table 2 demonstrates the Person correlation coefficient of each variable. Except for LEV, other explanatory variables are all highly correlated to R&D and explain much about the enterprise technological innovation. In additional, among the explanatory variables, the absolute value of Pearson correlation coefficient is between 0-0.3. Lind *et al*. (2002) considered the threshold value of collinearity is 0.3. So the study can get the result that though the explanatory variables present a certain level of correlation, collinearity is not existed.

From the results of model 1, 2, 3, except for asset-liability ratio, the enterprise characteristic variables show significant influence to the technological innovation and so do enterprise governance variables. The specific performance is as follow: size negatively affects the technological innovation investment, which is contrary to Schumpeter, but in line with that of Ning and Jing (2009). It can be attributing to the small scale of enterprise, which can be more flexible and face more competition, so that are more willing to implement technological innovation. TOBINQ is positively related to the investment of technological innovation. MSH and enterprise technological innovation are positively related to each other, that indicates the option incentive is efficiently connected the benefits of executives and shareholders and motivate the innovation. The coefficient of State is negative, which means state-owned companies are not in favor of technological innovation. The positive coefficient of Share means large shareholders are more intended to get high and long-term returns though the implementation of innovation.

Regression results and analysis: The regression results are given in Table 3. Model 1, 2, 3 is the regression results of equation 3. Model 1 is regression whose explanatory variables are just HHI and HHI^2 and model 2 is added enterprise characteristic variables, on the basis of model 1. Model 3 is added enterprise governance variables on the basis of model 2. Seeing from the regression results, coefficient of HHI^2 is negative and is significant in the level 1%, which indicates that the product market competition is reverse U-shaped related to technological innovation. Excessive monopoly would make the companies generate a scene of complacency and reduce technological innovation; with the increasing of competition, the technological innovation would be improved; when the competition develop to a certain level, increased competition can no longer improve the efficiency, but harm the enthusiasm of innovation, which is detrimental to technological innovation. Therefore, excessive competition and

excessive monopoly is not beneficial to technological innovation for the listed companies in China.

CONCLUSION

Since the proposal of Schumpeter's innovation theory, the relation of innovation and competition always attract attention. The study is based on sample collected from shanghai and Shenzhen non financial listed companies during 2002-2010; HHI is used to measure product market competition and enterprise R&D investment is used to measure enterprise innovation; the aim is to analyze the influence of product market competition, to enterprise technological innovation. The results reveals: excessive competition would hurt the enthusiasm of companies and influencing the technological innovation, while excessive monopoly would make the companies generate a scene of complacency and reduce technological innovation. Therefore, the product market competition is reverse U-shaped related to technological innovation. In addition, enterprise characteristic variables and governance variables all affect the enterprise technological innovation. The scale of enterprise negatively affects its innovation and small scale companies are in favor of innovation. The more chance the companies get to grow, the more innovative activities they carry out. The liabilities rates of companies have no effect on innovation. The proportion of independent directors is positively related to technological innovation and independent directors begin to play a role on improving the innovation. The increasing of the ratio of executive shareholdings and option concentration will promote the technological innovation, while state-owned just the opposite.

Above all, for the purpose of improving enterprise technological innovation, monopoly industries should further reduce the entry barriers and enhance competition to avoid unwillingness of innovation result from excessive monopoly. Excessive competition industries should be lead to enhance the protection of intellectual property and gain competitive advantage through technological innovation. At the same time, measures should be taken to consummate the governance structure of listed companies, for example, enhance the independent director system, implement option incentive to executives, reduce the proportion of stated-owned shares; increase the ownership concentration.

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