The Relationship Between Innovation and Competition: Empirical Evidence from the Taiwanese Manufacturing Industry

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Some researchers demonstrate that there is a positive relationship between competition and innovation; however, others depict that it is negative. Two contradictory results exist at the same time. Moreover, there are studies which show that the relationship is nonlinear. This study is to explore this relationship by examining the empirical data in Taiwan. We use Curve Estimation and Logistic Regression to investigate this relationship. We find an inverted-U relationship in this research. Our contribution can help clarify the relationship between innovation and competition.

Field of Research: Economics, Industrial Economics.

1. Introduction

The relationship between competition and innovation has been discussed for many years. Innovation is recognized as a major force to achieve success of organizations in the intensively competitive environment. Schumpeter (1943) is known as the first to well explore this relationship.

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He thought admired small entrepreneurial firms which achieve profits from their mostly radical innovations. He also mentioned that there is a negative relationship between competition and innovation. On the contrary, Arrow and Scherer (1967) depicted that it is positive. However, there are other studies which discover nonlinear connections. It seems that there is still no consistent theory to well describe the relationship between competition and innovation.

Empirical researches also illustrated that the results are various in different countries or industries. This evidence is often understood as a sign of technological or economic determinism in innovation: different industries will follow different innovation patterns and these patterns depend on structural characteristics specific to each industry (Frag & Paulo, 2008).

This research is to explore the relationship between competition and innovation in Taiwan. In the economic system, the study of competitive response is essential for any understanding of business actions. Managers need to incorporate competitive responses into their financial projections as they decide to invest in new product markets, or their dreams of riches could easily turn into dust (Aboulnasr, Narasimhan, Blair, & Chandy, 2008). Furthermore, exploring the connection between competition and innovation would be useful for corporates to realize the competitive situations and help managers shape correct strategies toward opponents.

This study chiefly focuses on the complicated situations between competition and innovation in the Taiwanese manufacturing industry. With the rising number of research and development (R&D) manufacturing industries, competition within this sector becomes fierce. This has made it crucially important for top managers in Taiwan to orient their R&D manufacturing industries along the best future direction and to invest capital in the most profitable and needed items (Chen & Chen, 2008). Manufacturing firms have much higher propensities to patent than other types of firms. Specifically, machinery, electronics and instruments companies receive between four and ten times more patents at any given level of R&D than software companies receive (OECD, 2007).

The organization of this paper is as follows: Section 2 surveys the theoretical literature on innovation and competition, and highlights theoretical predictions on the relationship between competition and innovation. Section 3 presents our model to investigate the relationship. Section 4 illustrates the results and discussion. Final section shows conclusions.

2. Literature Review

2.1 Innovation

Firms undertake innovation to produce new product and make profit. The incentive to innovate is from the gain of profit when a firm invests in R&D. The concept of innovation differs from market structure, the characteristics of innovations, and the dynamics of discovery lead to seemingly endless variations in the theoretical relationship between competition and expenditures on research and development or the outputs of R&D (Gilbert, 2006). The process involved in innovation activities is kaleidoscopic, from manufacturing process and product enhancement, new market development, the acquisition of new materials, the adjustment of marketing strategies, organizational management reform, and changes in packaging design (Wang, Chen, Lin, Chiang, Hsieh, Cheng, & Shia, 2003). Innovation leads the creation of social and economic, and it is also the intersection of invention and insight. With technology improved, the intensive of market and globalization, innovation is the only way for companies to survive.

Schumpeter (1943) pointed out that innovation is brought about by new corporations through a process of creative destruction and particularly emphasizes the importance of innovation activities by large corporations. Innovation is also claimed to be the engine of growth (Aghion & Howitt, 1992, 1998). It is also defined as the product, service, or technical process, which business units produced (Yen & Chang, 2005). Subramaniam and Youndt (2005) indicated that innovation involves identifying and using opportunities to create new products, services, or work practices. In 2008, Koléda demonstrated the fact that the innovation size requirement has to be considered as a policy instrument, that it appears extremely important to consider the case when the innovation size has been made endogenous. OECD (2007) shows the definition of technological innovation: (1) bringing to market products that are technologically new for the company, or which represent significant improvements in technology, (2) implementing technologically new or greatly improved manufacturing procedures. There are other non-technological activities - strategy, organizational adjustment, product packaging texture and art design, marketing methods, etc. Therefore, we can regard innovation as commercialized invention.

Many studies concentrate on measuring innovation intensity. However, it is difficult to decide the best parameter to measure. A patent confers the right to exclude others from making, using, or selling the invention claimed by the patent for the term of the patent grant. If the new technology is patented, the inventor can assign the patent to another firm or license one or more firms to use the new technology (Gilbert, 2006).

2.2 Competition

Given the central role of competition in the economic system, the study of competitive response is essential for any understanding of business actions (Aboulnasr et al., 2008). Competition is usually considered as a factor of efficiency, and hence a growth factor. But, as is well known, perfect competition is not compatible with increasing returns, which are at the heart of the growth process, and monopoly rents are the real incentives to innovate and, hence, to create new methods and new products (Gaffard, 2008). For a given total market size, competition affects the effective market of a firm, its residual demand, and the elasticity of the residual demand faced by the firm (Vives, 2008).

Gaffard (2008) depicted that competition is an essential element of the mechanism required for economic changes to be successfully brought about. For a firm, competitors in the same market observe the information disclosed in financial market and could use the information to the detriment of the firm. For example, production processes, new products, new markets and segment sales result in disadvantages to the firm. It means that corporates have an advantageous position on bargaining power, service, quality and other conditions. The role of competition in enhancing efficiency has been highlighted in a series of models (Hermalin, 1992; Meyer & Vickers, 1997).
Competition is an indicator to illustrate the market structure. A commonly adopted indicator is the Herfindahl-Hirschman Index (HHI). The HHI is sum of the squares of the market shares of the companies in the industry. A high HHI index indicates that a few companies dominate the market and a low index indicates that the market is spread amongst many companies (Ghemawat, 2002). HHI is a tool to probe the competition of market. The US government

adpots the HHI to explore the posture of competition.

2.3 The Relationship between Innovation and Competition

According to the classical Schumpeterian viewpoint (Schumpeter, 1943), the monopoly deadweight loss is the price we have to pay. Competition stimulates firms to perform R&D monopoly power and motivate innovator to increase research and development activity, thus economic growth (Bucci, 2009). The perspective concerns the nature of change, the role of credit, the impact of monopolist practices, the function of prices and the source of viability of any process of change (Gaffard, 2008). Schumpeterian's viewpoint that large firms and concentrated market structures promote innovation is the subject of a voluminous theoretical and empirical literature, and the results often appear contradictory (Schumpeter, 1943; Gilbert, 2006). The Schumpeter hypothesis was a big contribution until the pioneering works of Scherer (1967) which depicted that the hypothesis has flaws.

Nevertheless, Arrow (1962) showed that a monopolist that is not exposed to actual or potential competition has less incentive to invest in R&D than does a firm in a competitive industry (Gilbert, 2006). Scherer (1980) argued that lack of competition leads to bureaucratic inertia that discourages innovation. Porter (1990) stated that competition is good for growth, because it forces firms to innovate in order to stay in business.

Aghion and Howitt (1992) found out the negative relationship, however drew an inverted-U shape in 2001. Later in 2005, they reexamined this relationship by using panel data and finds clear nonlinearities in the form of an inverted-U shape. Too much competition will raise the producer's incentive to integrate, however, by allowing nonintegrated suppliers to capture most of the innovation surplus (Aghion et al., 2005). Koléda (2008) highlighted the possibility using one patent's characteristic, the patent height, as an instrument for promoting innovation and growth. Researchers argue that competitive response to radical product innovations is inherently different from response to the incremental innovations that are typically studied in existing research. They introduce the dual concepts of market expansion and entry thresholds to develop new hypotheses about competitive response (Aboulnasr et al., 2008). However, rather than the conventional inverted-U relationship, Scott (2003) found the U relationship for U.S. industrial firms' investments in environmental R&D, where environmental R&D is any R&D with the goal of introducing innovations to reduce pollution.

Literature above depicts that there is no consistent result when exploring the relationship between innovation and competition. This study investigates this relationship by examining the empirical data in Taiwan.

3. Methodology

3.1 Databases

This study uses two databases in Taiwan: the First Taiwan Technological Innovation Survey (TTIS I) and patent databases from Taiwan Intellectual Property Office (TIPO). The TTIS I helps us to study the source of technological knowledge utilized by firms to be innovative. Patent databases provide the granted patents in Taiwan and give the guidance to measure the degree of innovation.

To indicate the relationship of competition and innovation, we combine TTIS I and patent databases. Be the patent assignees, TIPO obtains patents by a variety of applicants. Nonetheless, it does not keep a unique identifier for each patenting companies. We performed an extensive name matching exercise to identify the patent assignees in the citation database and link them to the firm names in the TTIS I. There are 606 items selected in this issue. We use the HHI to draw the competition of the manufacturing industry and calculate the sales turnover of these selected companies. The research databases are shows in Table 1.

3.2 Measuring Variables

3.2.1 R & D

Many empirical studies on the relationship between firm size and R&D have established a number of empirical patterns. Although some of these patterns have been subject to controversy, researchers have arrived at an identical view of R&D with respect to firm size.

Table 1. Research databases.

Dataset	Variables	Period	Number of Firm	Source
TTIS I (First Taiwan Technological Innovation Survey)	Data on innovation and competition	1998-2000	3400	The First Taiwan Technological Innovation Survey (TTIS I) help us to study the source of technological knowledge utilized by firms to be innovative.
TIPO	Patent data	1998-2000	40000	TIPO (Taiwan Industrial Property Office) offers granted patent data in Taiwan.

3.2.2 Competition

We use HHI index to measure market competition. The HHI is the sum of the squares of the market shares of the companies in the industry. As the result of computation is too small to use in this research, we multiply the HHI by 10^8. The columns of final data are company, sales, patents, market share and the squares of market shares.

3.2.3 Firm Size

The employees of companies are stressed in the endogenous growth theory. In the model of Aghion et al. (2005), employees are homogenous and each firm chooses its allocation of labor to maximize the current value of profits (Tingvall & Poldahl, 2006). We use the number of employees from TTIS I to represent the firm size.

3.3 Model

The model of this research is as follows:

$$INNO=\beta_0+\beta_1 CP+\beta_2 CP^2+\beta_3 SIZE+\varepsilon_i$$

INNO denotes the innovation degree measured by the number of patents. β_0 is the intercept. β_1, β_2 and β_3 are coefficients of measured variables. *CP* is the competition degree of market measured by the HHI and CP^2 is the square of the HHI multiplied by 10^8. *SIZE* represents the employees of company. ε_i is the residual.

4. Results and Discussion

Table 2 lists the descriptive statistics of the combined database which includes 606 items. *Size* consists of all companies from small to large scale. The values of innovation spread from 1 to 884. We find that the large companies in Taiwan have more granted patents than the small and medium enterprises (SMEs). The sum of top four companies' market share is not beyond 50%. It seems that enterprises operate in the Taiwanese manufacturing industry face to a competitive environment.

Table 2. Descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
SIZE	606	3	31376	1248.79	3084.277
INNO	606	1	884	5.83	15.977
CP	606	.000000820213	.137441594122	.003447663077	.0119614945666
CP^2	606	.0000672709868	1.88901917876	1.54415543869	1.29409493694

The correlation of this research exhibits in table 3. We find the correlation of *size, INNO*, *cp* and cp^2 are significant. But *year* is not significant to other variables and have low correlation. The meaning is that *year* would have low effect for companies to stimulate their innovation.

Table 4 presents the estimation results by Curve Estimation (Model 1) and Logistic Regression (Model 2). The Curve Estimation is our main method to illustrate this relationship and it is the common tool to test the second-order regression. We also utilize Logistic Regression to verify that our results are robust. Curve Estimation also indicates that relationship between competition and innovation by applying a second-order variable of the competition. The second-order variable of the competition means the direction of curve. Table 4 illustrates that the second order of *CP* is negative. It indicates that the curve is convex. The curve hence follows an inverted-U shape. The F-value of Logistic Regression is 66.053, and the p-value is 0.00. Curve Estimation is therefore significant. Moreover, the F-value of Logistic Regression is 19.748, and the p-value is 0.00. Logistic Regression is also significant. These results illustrate that our two models can well represent an inverted-U relationship between innovation and competition. The vertical line is the degree of innovation and horizon line represents the competition of market.

Table 3. Correlations.

correlations						
		SIZE	INNO	YEAR	CP	CP^2
SIZE	Pearson correlation	1	.200	-.004	.749	.576
	Sig. (2-tailed)		(.000)***	(.927)	(.000)***	(.000)***
	N	606	606	606	606	606
INNO	Pearson correlation	.200	1	.062	.247	.072
	Sig. (2-tailed)	(.000)***		(.126)	(.000)***	(.075)*
	N	606	606	606	606	606
YEAR	Pearson correlation	-.004	.062	1	-.014	-.003
	Sig. (2-tailed)	(.927)	(.126)		(.736)	(.934)
	N	606	606	606	606	606
CP	Pearson correlation	.749	.247	-.014	1	.900
	Sig. (2-tailed)	(.000)***	(.000)***	(.736)		(.000)***
	N	606	606	606	606	606
CP^2	Pearson correlation	.576	.072	-.003	.900	1
	Sig. (2-tailed)	(.000)***	(.075)	(.934)	(.000)***	
	N	606	606	606	606	606

Notes: P-values within brackets. ***, **, * indicate significance at the 1%, 5% and 10% level, respectively.

Table 4. Regression results.

Variables	Model 1 (Curve Estimation)	Model 2 (Logistic Regression)
Constant	3.093(0.02)**	0.102(0.919)
SIZE	0.556(0.578)	-3.723(0.376)
CP	11.325(0.00)***	8.213(0.00)***
CP^2	-9.342(0.00)***	-8.745(0.00)***
R	0.424	0.248
R^2	0.180	0.161
F-test	66.053(0.00)***	19.748(0.00)***

Notes: 606 observations in the manufacturing industry during 1998 to 2000. Dependent variable is *INNO* which means the number of patents. Predictors are *CP*, CP^2 and *SIZE*. We perform Curve Estimation (Model 1) and Logistic Regression (Model 2). *P*-values within brackets ***, **, * indicate significance at the 1%, 5% and 10% level, respectively.

Figure 1 depicts, based on our data, the dispersion chart of innovation and The relationship of innovation and competition is not fully a linear relationship. We further perform Curve Estimation and Logistic Regression and find a relationship that follows an inverted-U shape. The result of Curve Estimation is demonstrated in Figure 2.

Figure1. Dispersion chart of competition and innovation.

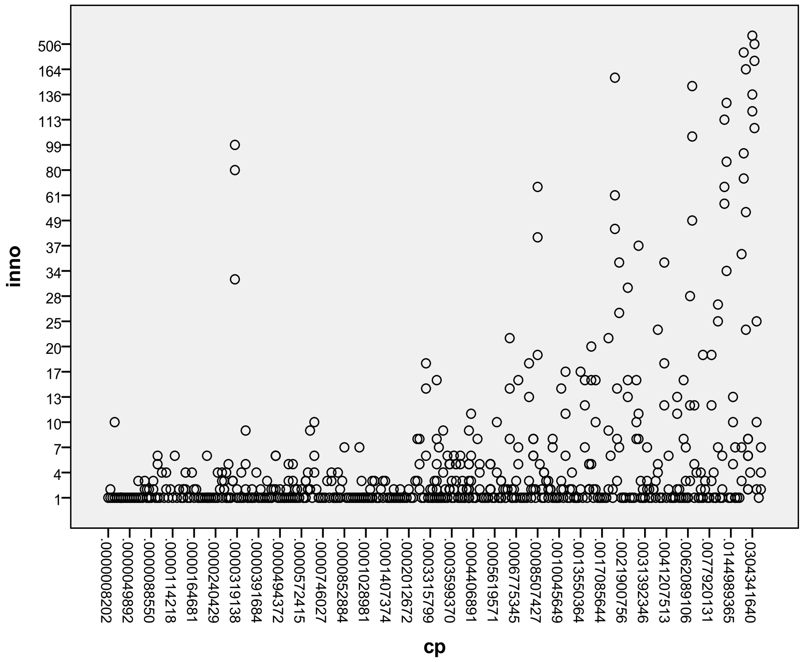
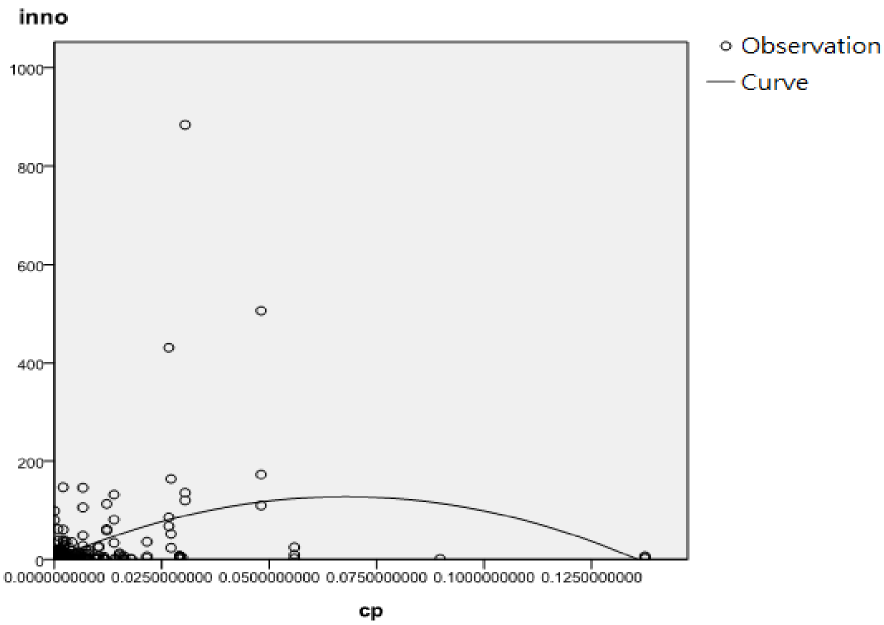


Figure 2. Inverted-U Curve of competition and innovation.



5. Conclusions

This research is to investigate the relationship between innovation and competition. Many researchers have interests in this topic, but they did not reach a consistent conclusion. The relationship is revealed as positive, negative and nonlinear. Our purpose is to further explore the connection by providing the empirical evidence in Taiwan. We combine two databases and 606 data are therefore included. We use Curve Estimation and Logistic Regression to verify the proposed model and demonstrate that the relationship between innovation and competition follows an inverted-U shape in the Taiwanese manufacturing industry. As the competition increases the innovation raises. The relationship is maintained until the turning point appears. After the turning point, the increased competition results in a decreased innovation. This study can help clarify the relationship between innovation and competition by providing empirical evidence in the Taiwanese manufacturing industry.

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