

# **Innovation and Profitability: Firm-Level Evidence from Taiwan**

## **Abstract**

This study investigates the relationship between firm's innovation behavior and profitability in Taiwan manufacturing firms over the period 2000-2010. The empirical results based on panel instrument variable (Panel IV) are summarized as below: First, innovation behavior has a significantly positive impact on firm profitability in Taiwanese manufacturing industry. Second, we separate patent modes into invention patents and design patents. It finds that the increase number of invention patents have a significantly positive effect on firm's profitability, while the increase number of design patents illustrate opposite effect. This result shows different patent modes have different impact on firm profitability for Taiwanese manufacturing firms.

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Key words: R&D, Invention Patent, Design Patent, Profitability

## 1. Introduction

The topic of innovation has attracted wide interest of economists since the seminal work by Schumpeter (1942), because innovation is widely recognized as a main driving force of economic growth as well as industrial evolution. Recently, firms have been investing in innovative behaviour input to enhance competitiveness. Firms possessing successful R&D strategies and patent rights can exclusively profit from the patented product within specific periods based on governmental regulations. In addition, product improvements or technical advancements in novel production procedures enable firms to obtain a relative advantage in the market, thereby facilitating firm operations and increasing profit (Nas & Leppälähti, 1997). Consequently, innovative firms are highly capable of protecting products that involved innovation investment and avoiding profit losses from intra-industry competition. In addition, because innovative firms can introduce diverse innovations on a long-term scale, they maintain a high profit standard (Love et al., 2009).

Nevertheless, although a spillover effect occurs in the process of successful R&D, the entitled profits of firms may be reduced because of competitive limitations. Furthermore, R&D investment involves focusing on unknown research targets. In addition to the inherent high risk, an innovative firm must bear the immense cost of R&D failures, which reduces the expected profits of the firm (Czarnitzki & Kraft, 2010). Therefore, the influence of innovative behaviour input on firm profitability requires further investigation.

Firm-level studies on the relationship between innovative behaviour and firm profitability have indicated that the profitability of innovative firms surpasses that of non-innovative firms. Relevant studies have adopted three common methods for measuring innovations: (a) patent number, (b) R&D investments, and (c) primary product or manufacturing process innovation. Regarding the first method, numerous studies have investigated data obtained from Finland (Leiponen, 2000), Canada (Cozzarin, 2004), the United States (Cefis & Ciccarelli, 2005), and Germany (Kruger & Rhein, 2009; Czarnitzki & Kraft, 2010) and found that owning patents is beneficial for increasing profitability. Concerning the second method, Hanel and St-Pierre (2002) and Rosenbusch et al. (2011) used U.S. data and found a positive relationship between R&D investment and firm profitability. Czarnitzki and Kraft (2012) referenced patent and R&D activity data from Germany and verified a significantly positive correlation

between innovative behaviour and firm profitability. Specifically, the patent inventory has a greater influence on firm profitability compared to the influence of R&D investment on profitability. Regarding the third method, Geroski et al. (1993), Roberts (1999), Love et al. (2009), and Cozza et al. (2012) respectively reviewed data that were obtained from the United Kingdom, the United States, Ireland, and Italy, and concluded that innovation has a significantly positive influence on firm profitability.

Most of these studies adopted samples from developed Western countries and supported the argument that innovative behaviour benefits firm profitability. However, Sohn et al. (2010) used South Korean samples and reached a contrasting conclusion, which stated that the R&D variable possessed a significantly negative influence on firm net return rates and the patents variable did not demonstrated a significant correlation to firm net return rates. This study proposed that these negative results were caused by hastily implementing R&D activities in underdeveloped industries. Consequently, the success rate of R&D was reduced, causing costs to rise and thereby negatively influencing profits.

Based on the mentioned research motivation and background, this study employed the structure-behaviour-performance analysis framework used in traditional industrial economics to verify the influence of innovative behaviour in Taiwanese manufacturing firms on firm profitability. We use R&D intensity (RDS) and the number of patent counts (PAT) as the proxy variable. Various national governments regulate innovative behaviour differently (i.e., the level of protection regarding innovative behaviour varies among countries). Therefore, because differences exist among the statutory protection provisions of various patents, which are mandated in accordance to the Taiwan Patent Act, the duration that patenting firms are permitted for consolidating profits also varies. Patents are further categorized as invention patents and new design patents. This study examined whether different types of patents exert a varying influence on firm profitability. In contrast to previous studies using data obtained from developed countries, this study focused on Taiwan, which is an emerging industrialized country. The results obtained can serve as a novel empirical reference in relevant literature.

The remainder of this paper is organized as follows. The next section provides a brief describe Taiwan patent act and innovative activities. Section 3 introduces data

source and the empirical model. The empirical results are presented in Section 4. The final section concludes with the main results and their policy implications.

## **2. Taiwan Patent Act and Innovative Activity**

### **2.1 Taiwan Patent Act**

The emergence of the Taiwanese patent system is traced to the Temporary Regulations on Business Awards, which was promulgated in 1896. However, patent regulations were first enacted when the Department of Industry and Commerce announced the Temporary Act for Arts and Crafts Awards in December 1912, which granted novel or improved products a 5-year exclusive right. In 1923, this act was amended by the Department of Agriculture and Commerce and called the Temporary Regulations on Arts and Crafts Awards. The act transformed the range and system of patents, and both inventions and improved products were provided patent protection. The complete regulations were promulgated in 1932. In an act amendment announced in 1939, utility model patents and new design patents were added to the scope of patents. The first Taiwanese Patent Act was formally established on May 29, 1944 and became effective on January 1, 1949. Numerous revisions have been added, which eventually shaped the current Patent Act. Based on the content of the Patent Act, patents are divided into invention, utility model, and new design patents, which are respectively granted 20-year, 10-year, and 12-year protection terms.

Regarding the protection content of new design patents, Taiwanese authorities changed the Chinese title from “new design patents” (defined as “creations made regarding the shape, pattern, colour, or any combination thereof of an article to provide a visual appeal”) to “design patents” (defined as “creations made regarding the shape, pattern, colour, or any combination thereof of an article as a whole or in part to provide a visual appeal”) to conform to industrial and international practices of design protection. To encourage traditional industries in developing innovative designs that employ existing resources, respond to the requirements of mature product-development designs in domestic industries, and reinforce protection of design patents, Taiwanese authorities referenced partial design regulations of patent acts promulgated in Japan, South Korea, and the European Union. Consequently, partial designs became protected in accordance with the Taiwanese Patent Act. In

addition, authorities asserted that the function of associated new design patents is limited to verifying the scope of original new design patents, and that no other tangible protection is provided. Therefore, regulations regarding associated new design patents were removed based on the practices implemented by the Japanese Patent Office. Finally, to conform to domestic industry development and international trends in design protection, computer graphics and graphical user interfaces became protected in accordance with the Patent Act. Thus, the most recent amendment of the Patent Act modified the regulated content, and the title of “new design patents” was changed to “design patents”. This amendment came into effect on January 1, 2013.

## 2.2 Taiwan’s innovative activity, 1995-2010

Before turning into the micro data, econometric model and specification, this section reviews recent trends of innovative activities in aggregate data. Taiwan’s postwar economic miracle is a well-known story among economists. The nation adopted the industry development model of OEM (original equipment manufacturer), for firms to make products under contracts for multinational corporations, which then market the resulting product under their own brand names. Taiwanese firms have learned and adopted foreign technologies to improve technological capabilities, which have been gradually associated with low-tech, imitative behaviors, for a long time. This means that these firms do not have to shoulder the burden of high R&D expenses.

We cannot infer from this that there is no active R&D or innovations taking place in Taiwan. Indeed, the government ever since the early 1980s has undertaken several measures to actively support industrial R&D. There were a surge of innovative activities by both private and public sectors in the past two decades, resulting in an excellent performance on innovation outputs. This island has therefore graduated from imitation to innovation by building its indigenous technological capability and raising the level of technology.

Table 1 displays Taiwan’s innovative activity since the mid-1990s. The second and third columns show trends in aggregate R&D spending and the ratio of R&D spending to GNP, respectively. The amount of R&D expenditure has increased more than three times - from NT\$125.031 billion in 1995 to NT\$394.960 billion in 2010.

The increasing trend on R&D expenditure reveals that a great effort for scientific and technological development has devoted in Taiwan. Accordingly, the ratio of R&D spending to GNP went from 1.78% in 1995 to 2.91% in 2010, it was a little higher than corresponding ratios of 2.77% and 2.64% in the U.S. and Germany in 2008.<sup>1</sup> The increasing trend indicates that R&D activity is increasingly emphasized in this island.

[Insert Table 1 about Here]

Concerning the innovative outputs, the number of U.S. patents, in which it is usually the case that patents are sought first and foremost (where the standards for patentability are more stringent and the largest export-targeted country). The right column of Table 1 shows that the number of successful Taiwan patent applications increased sharply. The growth in the annual number of patents is very impressive, starting from 1620 in 1995 to 8239 in 2010. In terms of patent counts, Taiwan's U.S. patents ranks 4th in the world since the year 2000, following U.S., Japan, and Germany.

Up to now, Taiwanese manufacturing firms have been successful in closing the technological gap between them and their counterparts in developed countries, especially in the electronics industry. Whether and how do such innovative behaviors affect firms' profitability? The Taiwan evidence can serve as an interesting example for the longstanding debate.

### 3. Empirical Framework, Estimation Technique and Data

#### 3.1 Empirical specification and estimation techniques

To estimate the effect of innovation on profitability of firms, this study refers to previous studies that discuss the determinants of profit and then specifies the following equation:

$$\begin{aligned}
 PROFIT_{it} = & \alpha_0 + \beta INNO_{it} + \alpha_1 SIZE_{it} + \alpha_2 AGE_{it} + \alpha_3 CAP_{it} + \alpha_4 ADS_{it} + \alpha_5 HUM_{it} \\
 & + \sum_t \delta_t D_t + u_i + \varepsilon_{it}
 \end{aligned} \tag{1}$$

The dependent variable  $PROFIT_{it}$  denotes the profitability of firm  $i$  in year  $t$ . Both theoretical and empirical studies have identified various determinants of

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<sup>1</sup> The R&D expenditures attributable to the business enterprise sector accounted for 70.68% of the total in 2008. Moreover, Taiwan's R&D/GDP ratio increased to 3.01% in 2012.

explanatory variables. Because this study examines the marginal effect of innovation on profitability of firms, the innovation INNO is the primary variable in Eq. (1). How does one measure a firm's innovative activity? We use R&D intensity (RDS) and the number of patent counts (PAT) as the proxy variable.

Other explanatory variables include firm size (SIZE), firm age (AGE), capital intensity (CAP), advertising density (ADS) and human capital (HUM). The size of a firm is measured by the logarithm of employment. Based on the Economies of Scale Theory, large firms often use a large amount of production and diversified production lines to reduce their production costs, and further maximization of the firm profit. Therefore, we should observe a significant positive relationship between firm size and their profitability (Stoneman and Kwon, 1996; Cozzarin, 2004; Cefis and Ciccarelli, 2005; Love et al., 2009; Czarnitzki and Kraft, 2010; Sohn et al., 2010). However, Penrose (1959) and Marris (1964) argued that firms can increase their product variety to achieve economic of scale. However, the inefficient management skill may increase the manufacture costs when entering into a new market and further lower the firms' profitability. Goddard et al. (2005) pointed out that when firm try to expand the market share, competitors will aware about erosion in their market share and regulator control may also increase the difficulty for the firm to expand its market share, and further increase the manufacture costs and lower their profitability. Firm age (AGE) is surveyed year minus the starting year. We use AGE as the proxy variable to investigate the learning-by-doing effect which proposed by Jovanovic (1982). The cumulative learning experience for old manufactures tend to help their operating, and further increase their profitability. Thus, it indicates a positive relationship between firm age and profitability (Kruger and Rhein, 2009 ; Love et al., 2009 ; Rosenbusch et al., 2011).

The term CAP denotes capital intensity of a firm, measured as the logarithm of physical capital per employee. We use this to measure entry barriers. Theoretically, automation increases production and cuts costs, thus manufacturers with more automation equipment are more productive and competitive. Therefore, we should find a positive relationship between capital intensity and firms' profitability (Leiponen, 2000; Cefis and Ciccarelli, 2005; Love et al., 2009; Sohn et al., 2010). However, several previous studies argued capital intensity has a negative impact on manufacturers' profitability owing to inefficient use of assets in Taiwan. Advertising

density (ADS) is measured as proportion of advertising expenditure on sales. Miller (1969) emphasized increase advertising spending can increase product visibility and market demand, and therefore increase firm's profitability. Previous study also found positive relation between advertising density and firm profitability. Human capital (HUM) is defined as the logarithm of wage per capita. We use it to measure the level of human capital for each firm. Through personal development and training programs, manufacturers can improve their profits and increase their competitiveness. To avoid the potentially endogenous problem in explanatory variables, all variables except for firm age enter the equation in the form of lagged one-year. Finally, a series of year dummies are also included to capture relevant unmeasured features on affecting profitability.

Because differences exist among the statutory protection provisions of various patents, which are mandated in accordance to the Taiwan Patent Act, the duration that patenting firms are permitted for consolidating profits also varies. Patents are further categorized as invention patents and new design patents. Therefore, to further investigate the potential differentials for the profitability effects between different types of patent, we separate patent into invention patent (PAT-I) and design patent (PAT-D).

One econometric problem that suffers in the estimation procedure is that there is an endogenous causality between INNO and PROFIT. Therefore, we use the Wu-Hausman test to detect the existence of an endogenous problem. If there no endogeneity is found, we adopt the technique of the panel fixed effect model to deal with the unobserved firm heterogeneity. Correspondingly, as the endogeneity problem has been detected, the panel instrumental variable (IV) provides an alternative technique.

### 3.2 Data Source

To implement the microeconomic analysis, this paper has collected unbalanced panel data of 641 manufacturing firms listed on the Taiwan Stock Exchange (TSE) over the 2000-2010 period, containing 6983 observations. Information on firm characteristics was obtained by matching various data sources. R&D and firm-specific variables, including employment, date of establishment, fixed



capital stock, and profitability, were acquired from the databank constructed by the Taiwan Economic Journal (TEJ).<sup>2</sup> The patent data can be drawn from the Taiwan Intellectual Property Office (TIPO) database to match to the accounts data for TSE firms.

Is our sample a reasonably representative of Taiwanese industrial R&D activity? As is well known, Taiwan's manufacturing sector is composed by an extremely high ratio, nearly 98%, of small and medium-sized enterprises (SMEs), while R&D spending and patenting have historically been highly concentrated in larger industrial firms. Arising from the conditions for Initial Public Offerings (IPO), most of the firms listed on TSE belong to the classification of large enterprises. Moreover, the sample includes most of Taiwan's leading R&D-performing firms, which we believe to be representative of industrial R&D activity. The definitions and basic statistics of variables are summarized in Table 2.

[Insert Table 2 about Here]

#### **4. Empirical Results**

Table 3 reports a series of estimates of the profit equation specified in Equation (1) for all firms. Results in model (1) and model (2) are obtained by the fixed effect (FE) model and the panel fixed IV, respectively. Before discussing the impacts of determinants, we first carefully assess the endogenous problem between INNO and PROFIT. Using the hausman test, the statistic value indicates an endogenous causality between innovation behavior and firm's profitability.

[Insert Table 3 about Here]

To what extent does the R&D activity enhance firm's profitability? We first looked at the variable of concern in this study: INNO. The estimated coefficients for the R&D intensity variable in model (2) is positive and statistically significant at least at the 10 % statistical level, after controlling for other potential influences. The result shows that innovation behavior is an important influence on firms' profitability, implying that there is potential profit-enhancing effect of firms' R&D activities. This

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<sup>2</sup> The Taiwan Economic Journal is a commercial company that has a fine reputation for collecting and summarizing information for companies listed on the Taiwan Stock Exchange. The TEJ databank is reliable and widely adopted by most universities in Taiwan and in financial sector firms. This databank contains comprehensive information for balance sheets, financial statements, annual reports, and so on.

finding is consistent with U.S. case (Hanel and St-Pierre, 2002; Rosenbusch et al., 2011). Moreover, the coefficient for INNO in model (2) is 0.4376, which suggests that as the R&D intensity increases by 1%, a firm's profit increases by about 0.43%. Compared with result shown in model (1), the coefficient on INNO variable is still significantly positive, but the estimated coefficient decreased sharply from 0.4376 to 0.0771. Thus, if the endogenous problem is not taken into account, the estimate results would suffer estimation bias.

The estimates for observed characteristics show similar results for all estimates. The negative effect of firm size on profit shows small firms generate higher income than large firm. This finding is consistent with Penrose (1959), Marris (1964) and Goddard et al. (2005). The coefficient of CAP is also negative and significant at the 1 % statistical level, indicating labor-intensive firms have better profitability. It shows firms should improve the efficiency of assets utilization in order to enhance their profitability. Table 3 also shows positive and significantly relationship between advertising density and firm's profitability. It provides evidence that firm can raise awareness through advertising and media, and further improve their profitability.

In view of innovative output, we use patents as a measure of innovation. In order to solve the endogenous problem of innovation behavior, this study use IV estimation method and results are listed in Table 4. In Table 4, model (3) to model (5) report the estimation results of the total number of patents, the number of invention patents and number of design patents, respectively. Model (3) shows significantly positive coefficient on the total number of patents (PAT). It suggests firms investing in R&D and successful innovation obtained a patent, and the patent protection granted by the government which can actually improve firm's profit performance. Moreover, model (3) shows the PAT coefficient is 68.17, it indicates each additional patent can increase the firm's profit by 68.17%.

[Insert Table 4 about Here]

Model (4) and model (5) further separated patent types and investigates the impact on firm's profitability. The result shows that the number of invention patents is significantly positive related to firm's profitability, while the number of new design patents is significantly negative related to firm's profitability. Specifically, model (4) shows the increase for each additional invention patent will increase firm's profitability about 45.9264%; however, model (5) shows the increase for each

additional new design patent will reduce firm's profit by 75.6160%.

The result in table 4 demonstrates different types of patents can have difference impacts to firms profit performance. As we find the increase number of invention patents indeed can help enhance firm's financial performance, whereas the increase number of new design patent generate opposite results and erode firm profits.

## **5. Conclusions**

This study investigates the relationship between innovation behavior and profitability for Taiwanese manufacturing firms over the period 2000-2010. We use the panel IV to overcome the endogeneity problem between innovation and profit variables. The result shows firm's innovation behavior has a significantly positive impact on firm's profitability in Taiwanese manufacturing industry. It provides evidence that firms investing in R&D and innovative behavior can help enhance their profit performance.

We then examine whether the increased number of patents obtained by the firm can increase their profitability. We also separate patent modes into invention patents and design patents. The results show both the total number of patents and number of invention patents can generate significant positive impact on firms' profitability. However, the number of new design patents produces negative outcomes. This result confirms the importance of patents modes obtained by manufacturing firms.

Table 1 Taiwan's Innovative Activity, 1995-2010

Year	R&D (NT\$ million )	R&D/GNP (%)					Taiwan's US Patents Granted, excluding New Design (rank)
		Taiwan	U.S.	Japan	Germany	Korea	
1995	125,031	1.78	2.51	2.71	2.19	2.37	1620 (7)
1996	137,955	1.80	2.55	2.81	2.19	2.42	1897 (7)
1997	156,321	1.88	2.58	2.87	2.24	2.48	2057 (7)
1998	176,455	1.97	2.62	3	2.27	2.34	3100 (7)
1999	190,520	1.98	2.66	3.02	2.4	2.25	3693 (5)
2000	197,631	1.97	2.75	3.04	2.45	2.39	4667 (4)
2001	204,974	2.08	2.76	3.12	2.46	2.59	5371 (4)
2002	224,428	2.18	2.66	3.17	2.49	2.53	5431 (4)
2003	240,820	2.31	2.66	3.2	2.52	2.63	5298 (4)
2004	260,851	2.38	2.59	3.17	2.49	2.85	5938 (4)
2005	280,980	2.45	2.62	3.32	2.48	2.98	5118 (4)
2006	307,037	2.58	2.66	3.39	2.54	3.22	6360 (4)
2007	331,386	2.62	2.68	3.46	2.53	3.21	6128 (5)
2008	351,405	2.78	2.84	3.47	2.53	3.36	6339(5)
2009	367,174	2.94	2.90	3.36	2.69	3.56	6642(5)
2010	394,960	2.91	--	3.26	2.82	3.74	8239(5)

Data source: Indicators of Science and Technology, Taiwan, various issues. US Patent and Trademark Office (USPTO).

Table 2 Variable Definitions and Basic Statistics 2000-2010

Variable	Definition	Means	S.D.
PROFIT	Profitability: ratio of profit to sales (%)	14.7500	77.8194
INNO	The number of total patent counts	9.4643	56.0156
PAT-I	The number of total invention patent counts	5.1979	32.8776
PAT-D	The number of total design patent counts	0.8251	7.1729
SIZE	Firm Size: the logarithm of employment	5.9856	1.2619
AGE	Firm Age: surveyed year minus the starting year.	26.8730	12.7014
CAP	Capital Intensity: the logarithm of physical capital per employee (NT\$ million)	7.7261	1.1776
ADS	Advertisement Intensity: the ratio of advertisement expenditures to sales (%)	0.5597	1.6291
HUM	Human Capital: the logarithm of yearly wage per employee (NT\$ thousand)	5.4497	0.8343

Table 3 Profit Effects of Innovation-R&D Activities

	FE (1)	Panel-IV (2)
INNO	0.0771* (0.0463)	0.4376* (0.2320)
SIZE	-9.8394 (2.6019)	-11.5818 (2.7040)
AGE	0.0485* (0.03882)	0.03345 (0.3914)
CAP	-7.0665*** (1.7284)	-8.4641 (1.6857)
ADS	0.5860 (0.9344)	3.9109*** (0.9774)
HUM	1.8154 (2.9169)	2.0092 (2.8887)
R <sup>2</sup>	0.0359	0.0420
Hausman Test		21.93* (p-value=0.08)
Obs		6122

Notes: (1). Figures in parentheses are standard errors. (2). \*\*\*, \*\*, and \* represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4 Profit Effects of Innovation- Panel-IV Fixed Effect Model

	(3) Total	(4) Invention patents	(5) Design patents
	All	Invention patents	Design patents
PAT	68.1700* (40.9588)	45.9264* (27.5941)	-75.6160* (45.4326)
SIZE	-31.2346** (13.0595)	-25.4891*** (9.7010)	19.3044 (17.7592)
AGE	-1.2349 (0.8758)	-0.8363 (0.6696)	0.4925 (0.4629)
CAP	-1.8902 (3.4853)	-1.6950 (3.5877)	-12.0235*** (3.5141)
ADS	-1.0673 (1.3512)	-.3021 (1.0675)	4.9611* (2.8060)
HUM	-12.9212 (9.1836)	-14.0677 (9.8392)	16.6668* (9.5247)
R <sup>2</sup>	0.0359	0.0359	0.0359
Obs	6151	6151	6151

Notes: (1). Figures in parentheses are standard errors. (2). \*\*\*, \*\*, and \* represent statistical significance at the 1%, 5%, and 10% levels, respectively.

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