

# Analyzing Taiwan's patenting performance: Comparing US patents and triadic patent families

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## ABSTRACT

*Issued patents are frequently maneuvered as indicators for measuring innovative technology development. These indicators are usually used by many internationally-renowned ranking institutions to measure innovative activities at country level. In those ranking results, Taiwan exhibits inconsistent performance by different indicators, ranking fourth by the number of USPTO-granted patents (US patents) but twenty-second by the number of triadic patent families (TPF). This study adopts a statistical method to verify Taiwan's patent performance as outlier among 40 major countries. We endeavor to explain the discrepancy between US patents and triadic patent families. Compared to other countries, Taiwan's ration of patents in triadic patent families to the US patent is lower than 40 countries in all technology fields. Moreover, Taiwan's international trading relationship with the US, Japan, and European Union cannot explain its extreme patenting performance. The study finds out that without a membership in Patent Cooperation Treaty (PCT,) Taiwan tends to shoulder more cost in applying multilateral patents, which may affect its quantity of patents in the European Patent Office (EPO) and Japan Patent Office (JPO), as well as the performance of TPF.*

**Keyword:** US Patent; Triadic Patent Families; Patenting Behaviour; Cross Country Analysis; Patent Performance.

## **INTRODUCTION**

What factors lead to Taiwan's patent performance to be dramatically inconsistent between the US Patent and Trademark Office (USPTO) and triadic patent families (TPF)? Observing results of different world innovative ranking systems, which adopted different indicators to measure patent productivity, Taiwan's innovative activity performance varied widely. Taiwan often performed better when the systems adopted the number of patent filed with the USPTO as an indicator, but worse when adopting TPF. TPF is a series of patent filed at the European Patent Office (EPO), Japan Patent Office (JPO) as well as the USPTO by the same inventor and applicant (Dernis and Khan 2004). The smaller number of TPF meant that Taiwan filed fewer patents with EPO or JPO. To answer the question why Taiwan's number of TPF was lower, the study had to further examine Taiwan's numbers of patent filed with EPO and JPO, and identified whether the filing behaviour caused inconsistent performance.

Some literatures studied patent filing behaviours to discuss the differences among patent performance. A report by Library of Congress (2005) indicated that patenting practices varied across technology fields. Furthermore, firms in different technology fields pursued different innovation strategies, influencing the patent filing behaviour (Peeters and van Pottelsberghe de la Potterie 2006). International trade is another factor affecting patent filing. Previous studies showed that the strength of patent right is a factor considered by international firms to export to a country (Awokuse and Yin 2010; Maskus and Penubarti 2005; Rafiqzaman 2002). Patent Cooperation Treaty (PCT) has become a crucial way to patent across patent offices since 1978. Members in PCT can file patents efficiently through a uniform procedure with several patent offices (Erstling and Boutillon 2006; Lapenne 2010). Thus, the number of patent filing through PCT has increased greatly during the last two decades (Hingley and Park 2003; WIPO 2010).

This paper discusses how Taiwan's patent filing performs differently with evaluations based on different patent databases (example: the US patents and triadic patent families). Since previous studies indicated that the patent filing behaviour was influenced by technology fields, international trade and facilitation from Patent Cooperation Treaty (PCT), this study reviewed the influence of technology fields, international trade, and facilitation from PCT in the literature review. Then, a regression analysis and a statistical test were employed to identify Taiwan's inconsistent patent performance with other countries. Furthermore, the study discusses those influences mentioned in the literature review on Taiwan's patent performance.

## **LITERATURE REVIEW**

The following sub-sections highlight Taiwan's varied performance in the various patent databases, the problems of using only a single database to evaluate the patent performance of countries, the strength and limitation of triadic patent families.

### **Taiwan's Innovative Performance**

Issued patents are frequently used as indicators for measuring technology development. Patent analysis shows regional or national technology development as well as knowledge transfer and spillovers. In recent years, patent-based indicators are extensively employed by government policy makers and industry analysts to study the change and direction of technology. The indicators are also used by many famous ranking institutions to measure innovative activities in countries, such as *Global Competitiveness Report* by World Economic Forum (WEF), *World Competitiveness Yearbook* produced by IMD Business School, *A new global ranking of the world's most innovative countries* by Economist Intelligence Unit, and *OECD Factbook and Science, Technology and Industry Scoreboard* released by OECD.

In recent years, Taiwan's innovation activity is becoming more prominent in the world innovative ranking systems which considered patent productivity as evaluation indicators. Taiwan is highly positioned in the reports published by various ranking systems, even though these systems adopted different data of patent statistics. For example, WEF's *Global Competitiveness Report* (Schwab 2010) counted the numbers of patent from the USPTO database, and Taiwan got the highest position in the 2010-2011 report by the indicator "Utility patents per million population." In addition, the IMD's *World Competitiveness Yearbook* (IMD 2010) adopted data revealed by World Intellectual Property Organization (WIPO), and Taiwan ranked 5<sup>th</sup> by number of patents. Furthermore, in *A new ranking of the world's most innovative countries 2009-2013* (Economist Intelligence Unit 2009), which counted patents in EPO, the JPO, and the USPTO, Taiwan ranked 6th for expected innovation performance index. In the 2004-2008 version, innovation performance was measured by patents per million population, in which Taiwan ranked 7th. In *OECD Factbook*, the number of triadic patent families in 33 OECD and 7 non-OECD countries were disclosed as a measurement of countries' R&D. Since retrieving patent data from a single patent office may cause bias, OECD developed triadic patent families, a set of patents filed at the EPO, JPO and USPTO, to measure the capacity of innovation of each country. Taiwan ranked 20th by the number of triadic patent families by priority year in *OECD Statistics Database* in 2007 (OECD, n.d.), a significant low position compared to those rankings measured by patents granted in the USPTO.

Taiwan's innovative performance varies from simple count of the US patents to

measurements based on triadic patent families. In 2005, Taiwan's patent number in the USPTO was over 38 times more than that in the EPO. Furthermore, in the rankings of patent counts, Taiwan ranked 3rd in the USPTO, 23rd in the EPO, and 21st in the triadic patent families. It shows that Taiwan issues patents only in specific regions but lacks of global strategy (Huang and Chi 2010; Tseng et al. 2009; Wang, Chen and Chen 2012). Although Taiwan's patent performance is inconsistent among different measurements, the number of Taiwan's patents granted at the EPO, JPO and USPTO have all increased significantly. From 1998 to 2007, Taiwan's number of patents grew from 3,805 to 7,491 in the USPTO, 1,777 to 2,225 in the JPO, and 41 to 147 in the EPO. This reveals that Taiwan's performances varies and are inconsistent among the different patent offices.

### **Patenting and Home Advantage Bias**

As a measurement of national or regional technological strengths, the number of patents is a commonly used indicator can be accessed through several ways, such as through the patent database of patent offices and commercial patent databases. Thus, the way of selecting appropriate databases for retrieving data of issued patents to evaluate countries' innovative performance has become an important issue. Since domestic applicants file more patents than foreign applicants do in most countries, the selection of specific database may lead to a country bias. According to the USPTO statistics report, US citizens comprised 53% of the US patents in 1997, while European Union citizens comprised 16.4%. On the other hand, in the EPO, European Union citizens accounted for 46.6% of patents filed at the EPO but United States citizens accounted for 28.7%. Such inclination that applicants tend to file patents in their home country's patent office are called "home advantage bias" (Dernis and Khan 2004). Hence, there will be controversies if someone only uses the number of patents issued by a single office as an indicator to evaluate innovative performance.

### **Triadic Patent Family**

In order to evaluate innovative performance more objectively, some indicators, such as "patent families" and "triadic patent families (TPF)" are further proposed. Patent families and triadic patent families both are methods to protect the same invention (Chen and Huang 2009). A patent family is a set of patents filed in various countries, and triadic patent family as defined by the Organization for Economic Co-operation and Development (OECD), is a series of patent filed at the EPO, the Japan Patent Office (JPO) as well as the USPTO by the same inventor and applicant. In other words, a patent files with the three patent offices are regarded as a set of triadic patent family (Dernis and Khan 2004). Patent families and triadic patent families could be used to evaluate innovative performance. These evaluation indicators not only eliminate the home advantage bias but also make a more objective international comparison. Patents in the triadic patent families are often of high quality,

because these patents need higher application process costs and maintaining fee, and applicants probably expect a higher economic value for the patent with higher cost (Sternitzke 2009). Triadic patent family is a common indicator used to analyze country-level patent performance, since triadic patent family is a strong indication for evaluating patent's value (Martinez 2010). Inventors tend to apply patents at more than one patent office only when the patents' value outweighs patenting costs. As a consequence, patent families or triadic patent families capture more important and practical patents than a single patent office (Popp 2007).

However, Frietsch and Schmoch (2010) proposed the limitation of triadic patent families that the USPTO publishes granted patents, while the EPO and the JPO publish applications. It is difficult to interpret the statistic report with different types of documents. Furthermore, taking only these three offices as consideration of indicator is doubted by several studies, and filing in national office of European country is generally more important than filing at the EPO (Sternitzke 2009). Other limitations may also have effect on the evaluation through counting number of patent family. For example, technical changing and policy changing influence patent filing, and not all research results will be patented but kept as invention secrets (Popp 2007).

### **Patenting and Technology Fields**

Some scholars asserted that the patent filing behaviour depends on the technology fields, while others claimed that it is influenced by corporate strategies. The Library of Congress's report (2005) stated that inventors in different technology fields tended to vary their patenting practices. In pharmaceutical industry, patents for life-saving and life-enhancing medical improvements were important factors, which lead a company to success and make the company get large amount of profits in a specific period. Software industry, on the other hand, was constricted by the multiplicity of patents related to a single finished computer product.

Jensen, Palangkaraya, and Webster (2005) argued that due to "disharmony," which was substantial procedural differences among different patent offices to examine patent applications, a single invention may be granted by a patent office but rejected by others. Among a dataset including 70,000 non-PCT patent applications granted in the USPTO and submitted to the EPO and the JPO, only 37.6% of the US-granted patents were affirmed by both EPO and JPO, and 0.6% of patents were rejected by both offices. Their study also showed different proportions of granted patents in different areas of technology. On the other hand, Peeters and van Pottelsberghe de la Potterie (2006) summarized that the patent behaviour depends on innovation strategies pursued by firms. In their empirical study, the

patenting behaviour was not significantly influenced by technological opportunity variables, which contradicted to a former hypothesis that the firm with high technological opportunity issues more patent than others.

Several patent statistics reports developed fields of technology by combining several classifications from specific classification system into a general field. For example, WIPO derived five fields of technology from International Patent Classification (IPC) symbols. The five fields are electrical engineering, instruments, chemistry, mechanical engineering, and other fields (WIPO 2008). The WIPO report (WIPO 2008) analyzed the number of foreign-oriented patent family in different fields of technology. For most of fields of technology, the origins of patent families are in the industrialized countries. China is the only exception in the top 15 list. On the other hand, this study employed another classification system: National Bureau of Economic Research (NBER) classification of technology field. NBER is derived from the United States Patent Classification (USPC), and it was used to analyze patent citation (Hall et al. 2001). The classification of NBER is further discussed in the Discussion of Technology Fields and Patenting.

#### **Patenting and International Trade**

Blind and Jungmittag (2005) summarized innovative strength as an important factor of trade performance for highly industrialized countries. In their study, Germany's innovative capacity influenced its export performance, because its idiosyncratic national standards of product made exports unfavorable. Companies patent their innovative knowledge assets bilaterally to increase control ability, avoid the imitation and competition from foreign countries and to ensure the monopoly. Foreign patent rights could also lead companies to internationalization effects, which increased exports and expanded the foreign markets (Smith 2001).

Maskus and Penubarti (1995) conducted an empirical research suggesting that exporting companies took local patent law into account when making sales decisions, and the strength of patent right is positively related to the export. Smith (1995) also mentioned that for the US firms, weak patent right was a barrier to export products. Rafiquzzaman (2002) used Canadian data to analyze the impact of patent right on the export. The result showed that the patent right is an important factor to the level of Canadian exports. With weaker patent right, the firms faced threats of imitation to their products. A related empirical study for China showed that exporters responded positively to the strengthening of international patent rights and the expansion of market power existing in China, especially to the knowledge-intensive sector (Awokuse and Yin 2010). Furthermore, the intellectual property right also plays a role in the domestic innovation rate in developed countries (Schneider 2005). However, the right might have a negative impact on the innovation in developing

countries. Hence, the developed countries benefit from the right to support their research and development activities.

### **Patenting and Facilitation from Patent Cooperation Treaty**

Patent Cooperation Treaty (PCT) administered by the World Intellectual Property Organization (WIPO) officially entered into force on January 24, 1978. It is a popular way to file a patent worldwide and to protect an invention in various countries. In the beginning, there were only 18 members, and the union grew to 142 PCT Contracting States in 2009 (WIPO 2010). The PCT system consists of two phases: the international phase and the national phase. The international phase includes application filing, international search, international publication and international preliminary examination process. According to the PCT procedure, applicants only need to pay a set of fees to complete the filing. It helps to save the time to file the same patent application in different patent systems.

The PCT provides a consistent and uniform procedure, a well-established standard over the world. The applicants can decide whether to apply in certain patent systems after getting the results of international search and preliminary examination. Hence, PCT can help firms to avoid unnecessary expenses (Erstling and Boutillon 2006). Lapenne (2010) stated that some important opinions on the PCT from filer aspect. For instance, Procter & Gamble (P&G), as a company owning a large amount of patent, mentioned that they benefited from PCT for obtaining sufficient time to gather information before making the decisions about patent application, which might be a high cost for the company. Furthermore, the company can reserve options whether to enter into the national phase. 3M also thought the PCT procedure was cost-effective for firms.

Due to the advantage of efficiency, filing through the PCT procedure has become popular. In 1978, only 636 patent filings adopted the procedure of PCT. However, the number reached 155,389 in 2009. Patents in the triadic patent families and other patent families highly employed PCT as a filing method (Hingley and Park 2003). In 2004, 68% of triadic patent families filed patents through the PCT system. The proportion of the US patents in the triadic patent families was 82%, and the EPC States accounted for 78% (Japan Patent Office 2009). The World Patent Report (WIPO 2008) indicated that the number of non-resident patent grants was around 319,429 in 2006, and the top three country of origin are Japan, the United States and Germany. Also, in 2006, the share of non-resident filings by PCT route is 48.9%. Furthermore, the top three PCT route users are the United States, Japan and Germany. Hence, the PCT route was an important route for applicants to file patent in non-resident countries.

## **METHODOLOGY**

The number of patents in the USPTO and triadic patent families of selected countries in this study were obtained from the USPTO and OECD respectively. The statistical analysis for US granted patents were subject to the year of patent application, and the “Patent Country” was set as the country of the first inventor’s residence. The study retrieved patent data from the USPTO’s Issued Patents databases, and the patents were applied during 1988 and 2007.

The statistical data for triadic patent families between 1988 and 2007 were retrieved from the OECD’s Patent Databases. OECD applies a geographical filter to define triadic patent families as a set of patents filed in the US, Japan and Europe. In the OECD’s original data, “Patent Country” is decided by the inventor’s country of residence. If there are multiple inventors sharing a patent, the calculation of patent country will be shared by each inventor. For example, if three inventors share a patent, two of which from Taiwan, and one from the US, the patent count will be two-thirds for Taiwan and one-third for the US. In order to make comparison with data from the USPTO, Patent Country for TPF was reassigned to the first inventor’s country in our analysis. The Patent Databases of OECD covered international patents across 37 OECD member countries and about 70 non-member countries, of which only 40 countries were provided with triadic patent families’ statistics report for recent years. These 40 countries were selected for a comparative analysis between the US granted patents and triadic patent families from 1988 to 2007.

A correlation test was used to measure the association of patent counts between USPTO patents and triadic patent families. In addition, this research conducted a linear regression based on data of triadic patent families counts (Y) and the USPTO patents counts (X) from 1988 to 2007. Since the distribution of sample data did not satisfy the normal distribution, natural logarithms of Y and X were applied. To identify outliers, extreme values in the regression, this study adopted Difference between the Fitted Valued (DFFITS) for a further examination.

Belsley, Kuh and Welsch (1980) proposed DFFITS as a diagnostic mean to describe the influential points in a statistical regression. DFFITS is obtained when the predicted value for a point is left out of the regression and studentized by dividing by the estimated standard deviation of the fit, denoted by the following formula:

$$\text{DFFITS} = \frac{\hat{y}_i - \hat{y}_{(i)}}{s_{(i)} \sqrt{h_{(i)}}}$$



A point with DFFITS greater than  $2\sqrt{\frac{p}{n}}$  is identified as an outlier, where p is the number of parameter of the model and n is the number of observation.

## **RESULTS**

### **Taiwan's Performances in USPTO and TRIADIC Patent Families**

The United States was the prominent country in both USPTO and triadic patent families with 1,518,404 USPTO patents and 372,524 triadic patent families from 1988 to 2007. Japan with 612,477 USPTO patents and 223,079 triadic patent families and Germany with 187,720 USPTO patents and 93,570 triadic patent families were ranked 2nd and 3rd respectively. Taiwan was the 4th for the US patents, with 78,796 USPTO patents. However, Taiwan had only 855 triadic patent families, ranked 22th by the number of triadic patent families (Table 1).

Figure 1 shows Taiwan's number of patents in the USPTO, JPO, and EPO for each year. There was an apparent discrepancy among the number of patents in the three patent offices. In recent 10 years, Taiwan's numbers of granted patent in the USPTO were much greater than the numbers in both JPO and EPO. Because patents in the TPF should file in all the three patent offices, small number of patent in the EPO is the cause of worse performance of Taiwan in the triadic patent families than in the USPTO patents.

The correlation coefficient between the USPTO patents and triadic patent families for the selected 40 countries was 0.98, which was significant at 1% significant level. Figure 2 shows the linear relationship between the US patents and triadic patent families from 1988 to 2007. The US, Japan, and Germany ranked as the top countries in both US patents and triadic patent families. Most countries performed linearly, closing to the line to all 40 countries. However, Taiwan was an outlier. Taiwan had outstanding performance in the US patents, while its performance was poor in the triadic patent families.

Table 1: Top Countries in US Patents and TPF from 1988 to 2007

Country	Number of US Patents	Number of TPF	Country	Number of US Patents	Number of TPF
United States (US)	1,518,404	372,524	Singapore (SG)	4,858	797
Japan (JP)	612,477	223,079	Norway (NO)	4,269	1,582
Germany (DE)	187,720	93,570	Russian Fed. (RU)	2,779	880
Taiwan (TW)	78,796	855	Ireland (IE)	2,431	772
Korea (KR)	74,049	9,789	South Africa (ZA)	2,204	543
France (FR)	69,798	38,961	New Zealand (NZ)	2,016	683
United Kingdom (GB)	66,041	32,675	Mexico (MX)	1,271	178
Canada (CA)	61,369	11,533	Hungary (HU)	1,176	597
Italy (IT)	29,772	12,943	Argentina (AR)	762	138
Switzerland (CH)	26,084	16,264	Luxembourg (LU)	636	287
Netherlands (NL)	23,921	15,673	Czech (CZ)	429	119
Sweden (SE)	23,431	12,681	Poland (PL)	390	145
Israel (IL)	16,702	5,177	Greece (GR)	383	124
Australia (AU)	16,418	7,366	Iceland (IS)	265	119
Finland (FI)	13,349	5,368	Slovenia (SI)	253	102
Belgium (BE)	11,263	6,875	Chile (CL)	235	40
Austria (AT)	9,493	4,186	Portugal (PT)	213	75
China (CN)	8,849	1,008	Turkey (TR)	187	70
Denmark (DK)	7,399	3,871	Romania (RO)	109	23
Spain (ES)	4,891	1,872	Slovakia (SK)	72	17

Note: Counted by the first inventor and filing date.

Figure 2 shows the regression of number of TPF on the number of the US patent. Most of 40 countries were above the regression line, such as Japan (JP), Germany (DE), France (FR), United Kingdom (GB), Italy (IT), Switzerland (CH), Netherlands (NL), Sweden (SE), and Belgium (BE), etc. The countries under the regression line were such as Canada (CA), Korea (KR), China (CN), Singapore (SG), and South Africa (ZA). All 40 countries, excluding Taiwan, distributed similarly indicating that countries with higher number of the US patent had higher number of TPF. However, Taiwan was the only country with a high number of the US patent but with a low number of TPF.

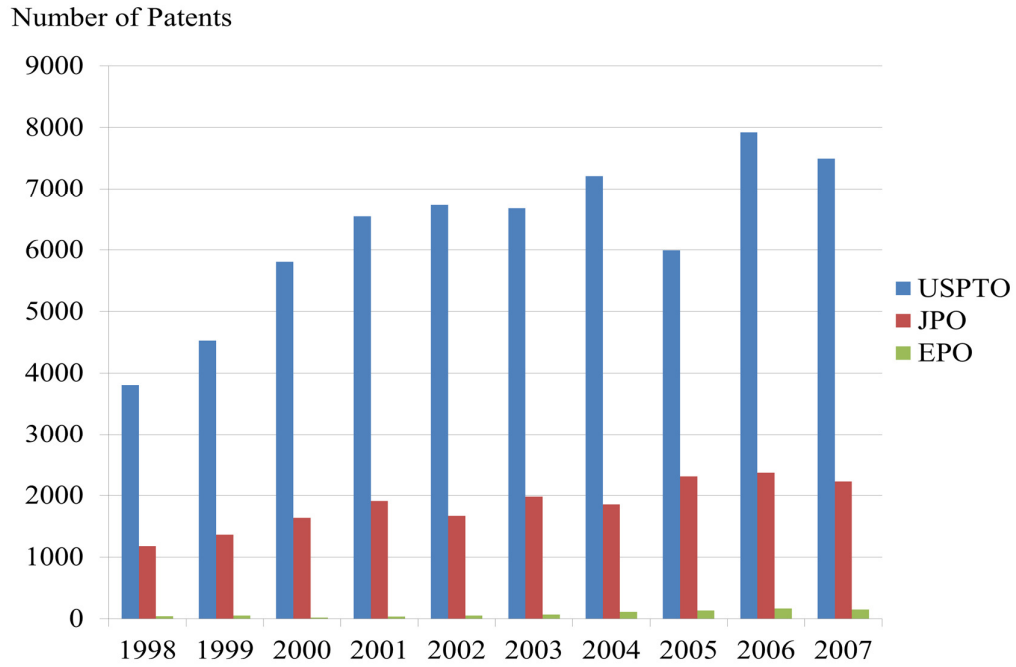


Figure 1: Taiwan's Number of Patents in USPTO, JPO, and EPO

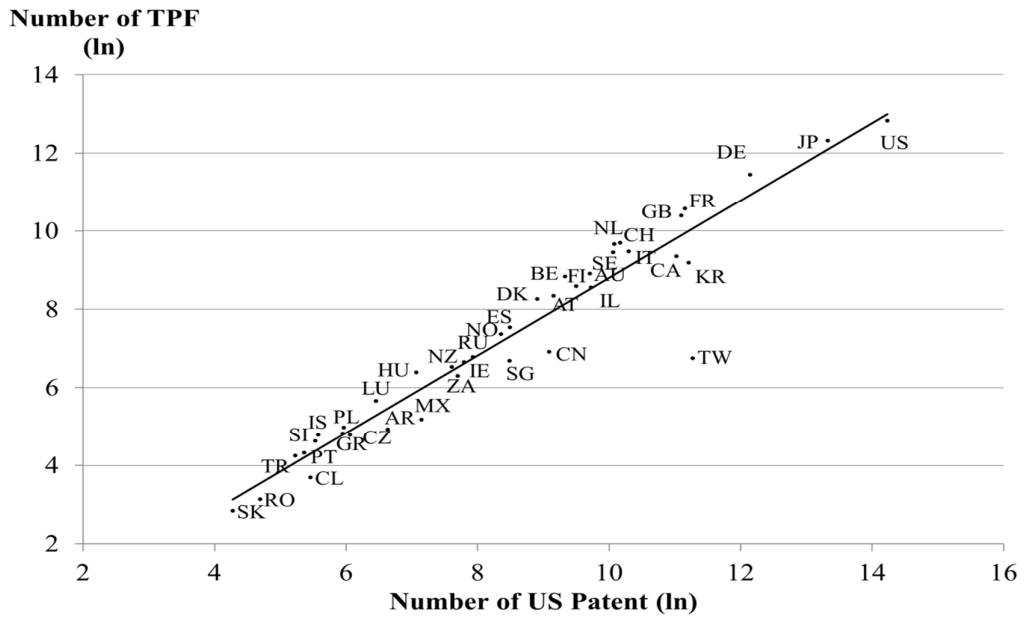


Figure 2: Scatter Plot of Number of US Patents and TPF from 1988 to 2007

The relationship between the number of patents in the USPTO and TPF was further examined by a linear regression:

$$\ln Y = -1.1139 + 0.9911 \ln X \dots(1)$$

DFFITS was tested for further analysis to examine countries with extreme performance. Belsley, Kuh, and Welsch (1980) suggested that the point which absolute value of DFFITS was above  $2\sqrt{\frac{p}{n}}$  is detected as an outlier. In our study, Taiwan's 20-year DFFITS was located in the outlier region, and even Taiwan's DFFITS of each year was proved as outliers. On the contrary, most of countries met the threshold of the 20 years' DFFITS, and some of which jumped into the outlier area up to three years' DFFITSs. They are closer to the boundaries than Taiwan's DFFITS, the farthest one to the threshold (Figure 3).

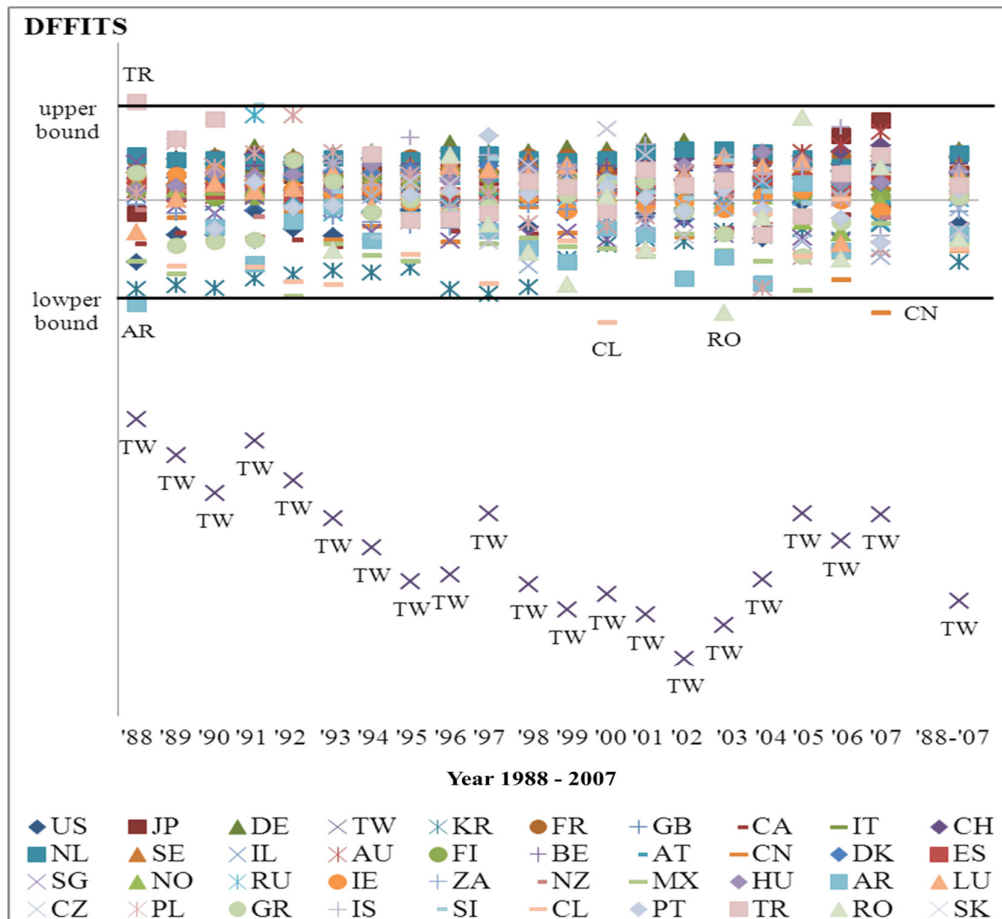


Figure 3: DFFITS between US Patents and TPF in 40 Countries from 1988 to 2007

Some countries have proven to show extreme performance of filing patents in triadic patent families only in a single year. Turkey had higher number of triadic patents in 1988, in which its DFFITS (0.4553) was higher than the upper bound (0.4472). On the other hand, some countries achieved lower DFFITS values. China's DFFITS (-0.5226) was below the lower bound (-0.4772) in 2007, Romania in 2003 (-0.5220), Chile in 2000 (-0.5656), and Argentina in 1988 (-0.4817). Although below the lower bound, they were still not too far from the lower bound. However, Taiwan showed extreme performance in every study year and in 20-year accumulated analysis. The lowest DFFITS for Taiwan was in 2002, which was -2.130; 20-year DFFITS was -1.860, and Taiwan was the only country not lying between the lower bound and the upper bound.

## DISCUSSIONS

### Technology Fields and Patenting

In this study, the classification of technology fields is developed by NBER. NBER divided 400 USPC classes into 36 two-digit technological sub-categories, and the 36 sub-categories are further divided into 6 industry sectors, including Chemical (excluding Drugs), Computers and Communications (C and C), Drugs and Medical (D and M), Electrical and Electronics (E and E), Mechanical, and Others. The NBER classification is more suitable for industry sector than USPC, because patents in the US patent system are not classified based on the industry of application (Hall et al. 2001).

Table 2 demonstrates the percentage of patents of six major technology fields in the USPTO and triadic patent families for 40 countries and Taiwan. In both US patents and triadic patent families, Taiwan performs better in Electronic and Electricity than in other categories. The number of Taiwan's patents in Mechanic field in the USPTO is relatively higher than that in triadic patent families. On the contrary, the patent percentages in the USPTO are lower than triadic patent families in Digital/Communication, Chemical, and Bio and Drug fields. For the whole 40 countries; however, six technology categories perform relatively consistent compared to the results of Taiwan.

Table 2: Percentage of US Patents and TPF in Major Technology Fields

	US Patents		Triadic Patent Families	
	40 Countries	TW	40 Countries	TW
Chemical	14.30%	7.04%	22.24%	13.92%
Digital/Communication	22.38%	15.53%	18.11%	22.11%
Bio & Drug	10.00%	2.33%	16.90%	14.04%
Electronic & Electricity	20.12%	38.75%	16.72%	25.61%
Mechanic	17.29%	17.30%	15.17%	12.40%
Others	15.90%	19.05%	10.86%	11.93%

In Figure 4, ratios of patents in triadic patent families to the US patents in six major technology categories are compared. The top 3 countries (the US, Japan and Germany) and Taiwan are highlighted in the figure. For the 40 countries, Bio and Drug is the highest category having TPF to the US patents. More than half patents filed in the USPTO are also triadic patent families. Chemical is the second highest; the rest are Mechanic, Electronic & Electricity, and Digital/Communication.

Germany has the highest ratios of triadic patent families to USPTO-granted patents in all six categories among countries, and the lowest ratio is found in Digital/Communication, still up to 37.75%. In fact, European countries have a higher ratio of triadic patent families than other countries. However, Taiwan has the lowest ratio of triadic patent families to the USPTO-granted patents in each category among 40 countries, even its highest percentage in Bio & Drug is only 6.57%. Taiwan's three major technology fields by proportion in the USPTO (Electronic & Electricity, Mechanic, and Digital/Communication) tend to patent fewer triadic patent families than all 40 countries.

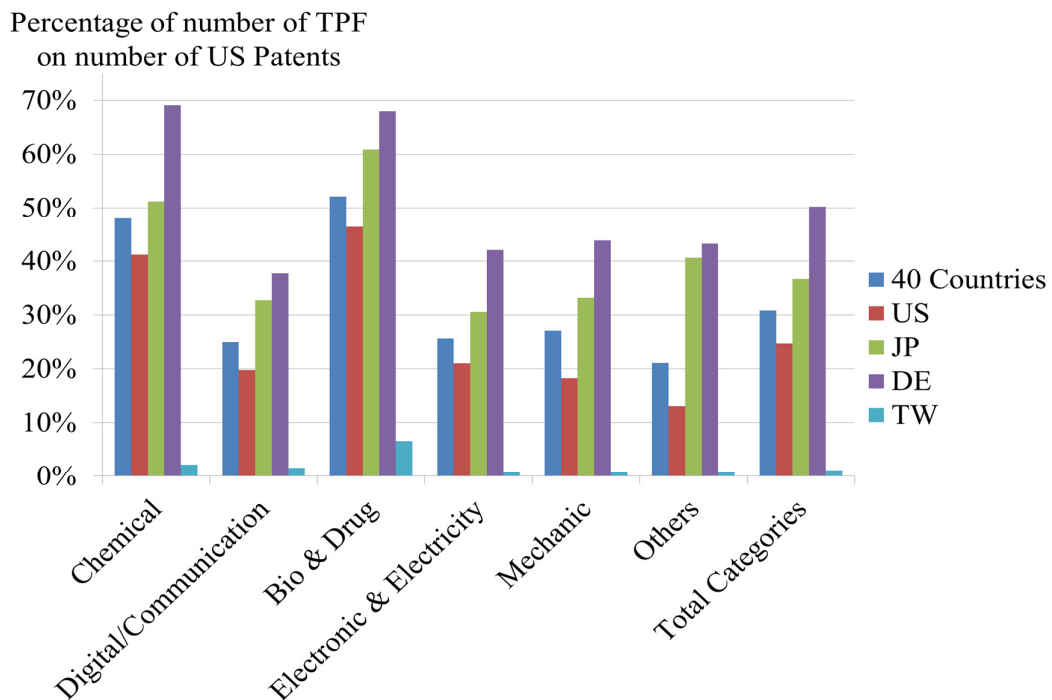


Figure: 4 Ratio of TPF to US Patents in six major categories in 1988-2007

All six technology categories have different ratios in patenting, but Taiwan has the lowest ratio in all categories. Therefore, Taiwan's extremely low performance in patenting does not

result from one single technology field but all.

### Patenting and International Trade

The US, Japan and European Union countries, where triadic patent families were filed, are Taiwan's major trading partners. Thus, firms in Taiwan would file more patents in these three economic entities. The share of these three countries' trading balance in Taiwan dropped from about two-thirds in 1988 to one-third in 2007 (Figure 5). Before 2001, the US, Japan and European Union had been Taiwan's top three trading partners. But since 2005, China became Taiwan's major trading partner with about one-sixth to one-fifth of Taiwan's trading balance.

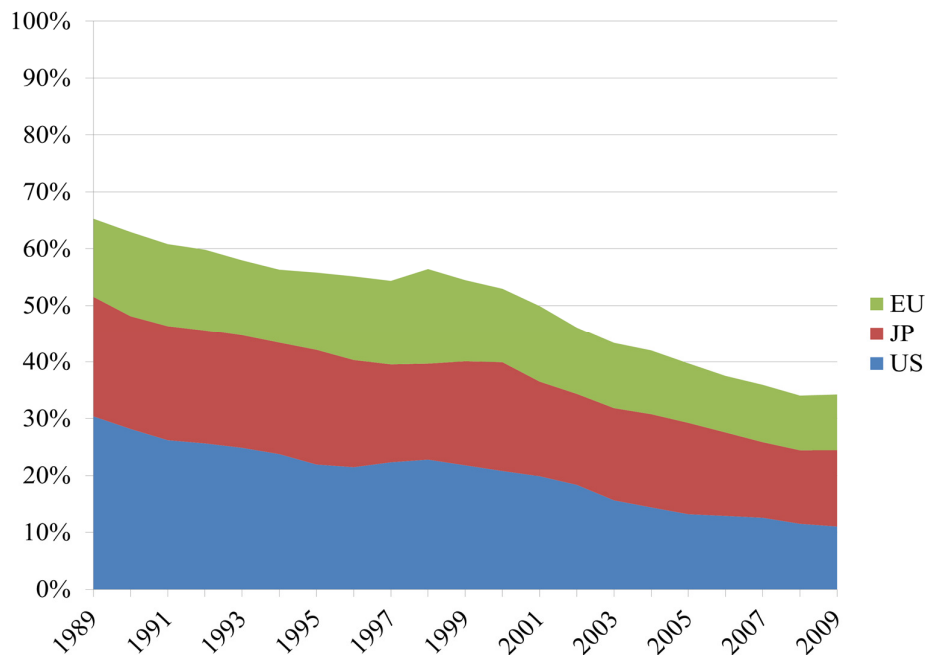


Figure 5: US, Japan and European Union's Shares of Taiwan's Trading Balance  
(Data source: Bureau of Foreign Trade, Taiwan. <http://cus93.trade.gov.tw/FSCI/>)

Although the US, Japan and European Union were Taiwan's major trading partners, they performed differently in trade balance: Taiwan posted a trade surplus to the US and European Union but a trade deficit to Japan (Figure 6). Taiwan had a trade deficit with Japan through 1988 to 2007, and the deficit amounts were over 20,000 million US dollars in recent seven years. On the other hand, both the US and European Union are Taiwan's important export destinations. Taiwan's constant trade surplus to the US renders the US a preferable patenting destination for Taiwanese; however, Taiwan has fewer filed patents in EPO, though Taiwan has a trade surplus to EU after 1998, in particular, when EU became Taiwan's major

export destination after 2007. Overall, Taiwan's patents played a dominant role in USPTO but an inferior role in EPO. This cannot be validated by the trading balance that Taiwan had trade surplus to both the US and EU.

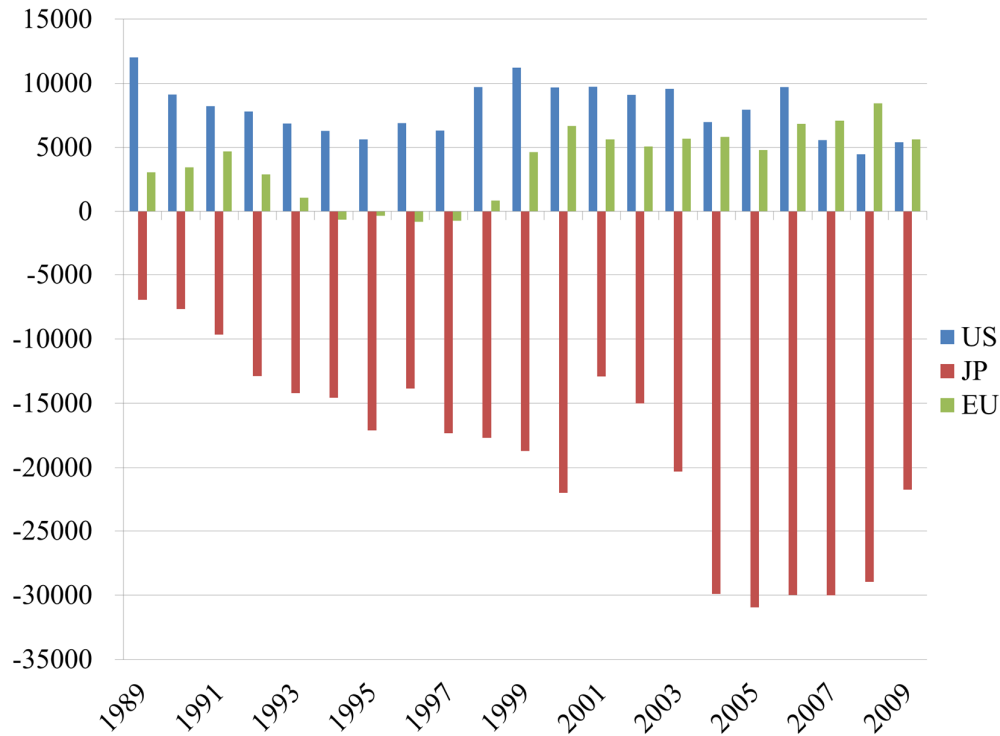


Figure 6: Taiwan's Trade Surplus (Deficit) with the US, Japan and European Union

### Patenting and Facilitation from Patent Cooperation Treaty (PCT)

Because Taiwan is not a member of PCT, it is difficult for Taiwanese inventors to apply patents through the PCT route. Thus Taiwanese inventors have to shoulder more application process costs to patent their inventions at other patent offices simultaneously. This could be a possible explanation for Taiwan's inconsistent patenting performance between the USPTO and the EPO, which are both Taiwan's major exporting countries. In addition, in order to file efficiently, some Taiwanese applicants file patents with other patent offices via PCT member countries such as the US, Singapore, and China. However, the number of patents filing via PCT members is still extremely small. For example, the number of Taiwan's patents filed with the JPO via PCT was only 52 in 2009; on the contrary, the number of patents filed directly with the JPO was up to 2,686. In other words, patents filed via PCT members account for less than 2% of the total filings of the JPO.



Furthermore, WIPO's report (2008) stated that, in 2006, more than 50% of non-resident patent was filed through PCT route. It showed that PCT was an important route to file patent in the EPO. Adding that Japan is Taiwan's third important trading partner, we may infer that the number of Taiwan's patents filed with the EPO may be smaller than that with the JPO via PCT member countries. Hence, it might be the cause of the gap between Taiwan's numbers of patent in the USPTO and the EPO, and the USPTO and TPF.

## **CONCLUSION**

There are three major contributions of the study. First, based on the literature review, the study examined possible factors, which influenced patent filing and identified important ones having effect on Taiwan's inconsistent performance. Second, except for Taiwan, most countries had positive correlation between the number of patent filed in the USPTO and TPF. Third, unlike previous studies for PCT, this study examined the role of PCT from an opposite view indicating a negative influence on Taiwan without PCT membership.

This study explored the discrepancy of rankings, which adopted different measurements to evaluate innovative activity performance. The ranking results showed that Taiwan performed well in the measurement based on the number of patents in the USPTO, while the measurement based on patents in triadic patent families generated extremely different results. This study employed patent data retrieved from the USPTO and OECD to compare Taiwan's performance based on different measurements compared with other countries' performance. Taiwan's number of patents filed with the USPTO, JPO, and EPO varied tremendously, with the most patents in the USPTO and the least patents in the EPO. Compared to other countries, Taiwan was the only economic entity whose ratio of triadic patent families to US patents was significantly lower than others tested by DFFITS. From 1988 to 2007, Taiwan's DFFITS of each year was far below the threshold of DFFITS and made Taiwan an outlier.

Taiwan performed well in Electronic & Electricity in that Taiwan had higher proportion in this category in both US patents and TPF than 40 other countries. However, Taiwan's patent share in each category was quite dissimilar. The percentage in Electronic & Electricity in USPTO was up to 38.75%, while that in Bio & Drug was only 2.33%. Comparing Taiwan's ratio of patents in triadic patent families to the USPTO with other countries indicated that Taiwan had extremely low percentages in each category.

Previous research showed that innovative capacity influenced the trade balance. The United States, Japan, and European Union were all Taiwan's major trading partners. Taiwan posted

a trade deficit to Japan during the past 20 years, and a trade surplus to both the US and EU. Nevertheless, the trade balance of Taiwan was not consistent with the performance of patent number in these three countries in that Taiwan's patents in the EPO were extremely fewer than the other two.

PCT plays an important role on patenting. Under the circumstances that Taiwan is not a member of PCT, applicants from Taiwan have to file patents directly with local countries respectively. Hence, they have to shoulder more cost through the application process. It could be one possible explanation for Taiwan's inconsistent performance in the rankings of the USPTO-granted patents and triadic patent families.

This study pointed out that the evaluation based on triadic patent families would not be consistent with the evaluation based on the US-granted patents. The discrepancy, or gap, might happen because some countries are not PCT members. This research used Taiwan as an example of a country in this dilemma, arguing that triadic patent families may not be qualified to represent the innovation performance of Taiwan.

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