

Exploring Influence of R&D Investment, Import and Export Performances to Patent Value

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Abstract--Patent valuation has been an important research topic in a globalized knowledge economy where intangible assets and internationalization plays crucial roles. The objective of this study is to understand how the two factors, which are 1) intangible assets: patenting activities and R&D investment, 2) tangible goods: international import and export, influence patent value. More specifically, several patent information, e.g. Number of Patent, Number of Inventors, Number of Patent Citation Received, charge and payment for the use of patent (from USPTO and World Bank), reflecting intangible asset, together with US import and export data (from UN-COMTRADE) reflecting globalized tangible goods are employed to test if the selected data have any explanatory power in estimating patent value. The results show that the correlation is positive and the explanatory power can be confirmed.

I. INTRODUCTION

Intellectual property rights have gradually become a popular issue in recent years. In several empirical studies, it has been demonstrated that there is a close association and considerable correlation between patent and economic performance in international markets.[1]–[4] For instance, based on a time longitudinal analysis of those countries selected for this paper, demonstrated that patent explained import and export streams. More specifically, this paper raises the question by means of whether export and import performance can be used as a bridge over macroeconomic performance and patent activity. Therefore, the overall aim of this study is to show whether different performance in import or export and R&D (Research and Development) investment have any explanatory power in estimating the patent value by observing the countries that have been selected in this paper. In addition, it can be expected that patents – as an output indicator of research and development process – are strongly related to the import and export performance of countries.

There have many patent litigation issues in recent years because we are in a globalized knowledge economy. For example, companies that perform cross-border trade in different countries often sue each other for patent infringement in order to protect the product. According to the research for litigation patents[5], which are considered more valuable patents than non-litigation patents, so this paper used litigation patents to be the main condition for searching data.

Fig. 1 shows the main purpose of this paper is exploring patent value through intangible assets and tangible assets. For searching data, tangible assets including two major databases (UN-COMTRADE (United Nations Commodity Trade) and World Bank database) and intangible assets' data is based on

the USPTO (United States Patent and Trademark Office) database. For tangible asset data, we used an integrated trade dataset that consisted of annual data of international trade from 1996-2013. This included eighteen nations and Hong Kong: (Korea, Rep., Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR (Special Administrative Region), Ireland, China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan and United States). The trade volume, R&D and patent performance data indicate the connection between national economy and patent value.

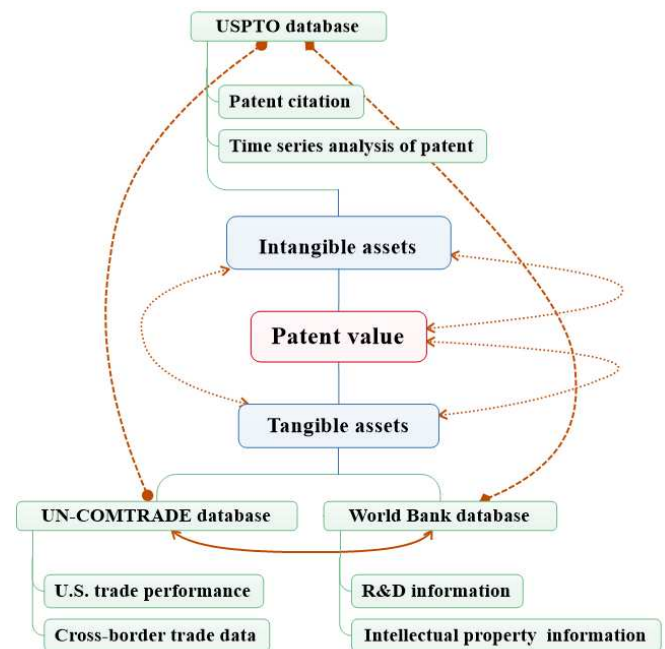


Fig. 1. Relationship between tangible assets and intangible assets (the lines is the relationship of each item; Double-arrows means the items can be effect by each other, circle and square mean they can be effect indirectly).

For patent data, this paper used USPTO database to build patent information, like patent citation[6][7] and the number of patents. This paper selected nineteen countries and HK (Korea, Rep. , Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR, Ireland , China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan, United States, Taiwan) that annually cited US litigation patents, then, this paper used eighteen nations and Hong Kong for the sample.

Furthermore, patent indicators were used – as an economic indicator to assess the strength of the various economies – this can also be an indirect assessment of the

value of the patent or indicate the strength of the various economies. This paper used the UN-COMTRADE database by HS1996 (Harmonized Commodity Description and Coding System) classification and World Bank database by researchers in R&D and charges for the use of intellectual property. Moreover, this paper used the USPTO database to search those patent information (query by SQL-server (Structured Query Language)), by litigation patent and patent indicators (using the nineteen nations stated above and HK).

II. LITERATURE REVIEW

A. Macroeconomic interaction with patents

With the growing trend toward globalization of trade, different countries according to their internal factors may have significant impact on FDI (Foreign Direct Investment) [9][10][11]. International patent behavior may have intensive and positive effect in international trade and exports investment [3]. Some studies have shown that macroeconomic patent statistics may rectify the influence generate from global knowledge[4]. In this study, we used the research method mainly cited from [1], discovered the relationship between macroeconomics performance and patent value.

B. Patent as the main analytical basis element

A large amount of research shows patents are valuable indicators [12]–[15]. In recent years, there are more and more transnational patent litigation issues emerging from development of globalization. In addition, litigation patents are more valuable patent has been proposed [5]. In this topic, reference from [5], also investigate litigation patents, and discuss if there is value in litigation patents or not.

C. Globalization R&D activities with patent performance

In the global knowledge economy, globalization R&D behavior surfaced in various countries frequently[16]. Some studies have shown that patenting activity is a direct product under R&D[17], and have a standard intellectual property rights system can provide an appropriate surrounding for multinationals[18][19]. In the globalized environment, the higher the technology has a better competitive advantage [20]. In this study, we also used R&D performance to demonstrate the effect between cross-border trade and litigation patents[18].

III. RESEARCH METHOD

In this section, US litigation patents are used as the main condition [5] and the US is selected as the target country[21], [22] this gives an expression how to explore the influence of these three factors: 1) R&D Investment[17], [23]–[26], 2) Import and Export Performances, 3) Patent Indicators, to

patent value because of these reasons: First, the US is one of the major markets in the world.[27] Second, the USPTO has sufficient quantity to collect patents around the world, with various fields that have high technical coverage. Third and also the most important factor is that litigation patents have been proved to be a more valuable type of patent than non-litigation patents in previous studies[5].

This study first downloads all USPTO utility patents issued from 1976 to 2013 (4,667,855 utility patents in total), then selected the top twenty countries annually cited by litigation patents from the US. The reason why this study selected those twenty countries is that this study wants to know the globalized knowledge economy mainly associated with the US, and from the results shown in Fig. 2, these countries are (Korea, Rep. , Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR, Ireland, Taiwan, China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan, United States) respectively, where vertical axis is number of litigation patents and horizontal axis is country. Through observation the number of litigation patents shows that only US has more than ten thousand patents citing from US litigation patents, and top five cited from US litigation patent countries are (US, Japan, Germany, Canada and UK) respectively. Furthermore, US is the country that most likely to cite the US litigation patent.

In order to explore the influence of R&D performance and cross-border trade to patent value, this paper also used some statistic methods like correlation coefficient and multiple regression analysis to demonstrate the relationship of those countries that this study chose.

IV. RESULTS AND DISCUSSION

This study compared some of those twenty countries in Fig. 2 to explore the linkage between intangible assets and tangible assets. First, this study used UN-COMTRADE database to select the US cross-border trade data with the world (all trade partners in the world), which illustrates that the US total trade volume has been on an upward trend since 1996, but it suddenly dropped in 2009, this could be attributed to the recession around the world.[28][29]

Apparently, the US had a high trade deficit, this implies that US economy mainly depended on import and the difference was larger over the years, the US needed more commodities from other countries to satisfy its demands. Table 1 demonstrates the mean and standard deviation of the year between 1996 and 2013 of number of country annually citing litigation patents in US, and US total trade volume by seventeen countries and Hong Kong (Korea, Rep. Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR, Ireland, China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan).

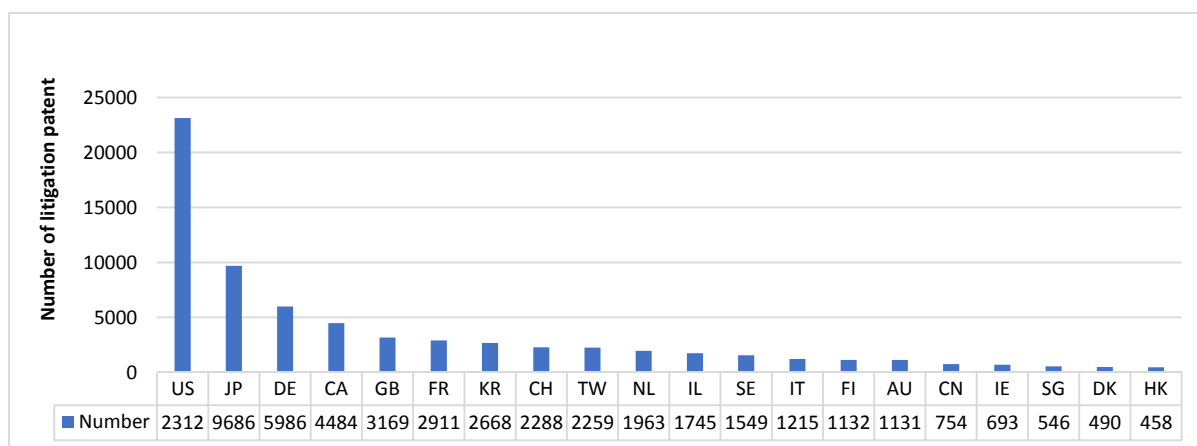


Fig. 2. Top 20 Country citing from US litigation patents, 1996-2013

Source: USPTO, own calculations.

TABLE 1. MEAN AND STANDARD DEVIATIONS FOR A SELECTED SET OF EXPORT & IMPORT PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 1996-2013 SOURCE: UN-COMTRADE, USPTO, OWN CALCULATIONS.

	Number of citing		US import value		US export value	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Japan	1677.3	276.0	133091.8	14140.1	60371.4	6002.7
Germany	501.8	196.4	77499.1	22453.6	36812.9	10544.4
Canada	374.0	165.5	256147.6	60165.2	207592.1	53278.9
UK	206.4	58.8	46905.5	8606.5	42807.3	7733.3
France	199.1	59.6	33799.8	8005.5	23434.0	5719.6
Korea	265.3	134.9	42980.2	12252.8	29931.0	7820.1
Switzerland	178.1	113.3	14823.9	6380.0	14521.3	6836.4
Netherlands	144.5	76.5	14679.6	5715.0	27998.2	9296.3
Israel	136.6	76.8	15978.5	5709.1	9779.6	3029.1
Sweden	121.9	35.9	10564.1	2286.0	4136.4	702.8
Italy	68.3	15.3	29304.9	6471.1	12099.7	2639.8
Finland	84.0	34.6	4080.3	1058.3	2217.2	641.8
Australia	115.2	84.4	7646.7	1875.8	17386.0	6206.3
China	42.7	50.8	237974.8	142030.7	50251.5	37350.1
Ireland	47.3	59.0	23779.0	10435.6	7207.1	1457.9
Singapore	47.5	39.4	17724.3	1965.6	22148.7	5865.6
Denmark	37.9	29.7	4655.8	1732.8	2005.2	400.1
Hong Kong	26.4	12.0	8289.2	2607.1	20287.8	9349.6

In Fig. 3 and Fig. 4, the horizontal axis shows the year from 1996 to 2013, while the vertical axis represents the cross-border trade with US. Fig. 3 and Fig. 4 illustrates the USs' cross-border trade performance, each color representing one country from that prior eighteen partners who annually cite US litigation patents, including (Korea, Rep. , Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR, Ireland, China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan). The higher rank they have, the worse the average performance.

These graphs display the volume of export (see Fig. 3) or import (see Fig. 4), the larger the area, the higher the volume of export or import. In Fig. 3, Canada accounted for the largest part of the export performance in US, followed by Japan, Germany and England. The total value of exports has been rising year on year. In Fig. 4, Canada and China accounted for the largest two parts of the import performance in US. And the most important section is to arrange the quantity of citing US litigation patent from more to less can

shows the fewer times they cited US litigation patents, the lower the effect of the import performance in US.

Table 2 shows the correlation between the number of countries annually citing litigation patents in US and the country's total value of imports and export in US (million). Table 3 demonstrated the regression coefficients analysis for a selected set of export and import performance and number of country annually citing litigation patent in US. In table 2, there are high correlation between these seventeen nations' and Hong Kong's (Korea, Rep., Israel, Italy, Sweden, Finland, Australia, Singapore, Denmark, Hong Kong SAR, Ireland, China, Netherlands, Switzerland, France, United Kingdom, Canada, Germany, Japan). This can be further illustrated by the fact that there are high values for litigation patents for research, state, import and export activities, and can utilize this data to collate Fig. 3, Fig. 4 and to prove the main purpose of this paper: The interaction between import and export performance and patents. In conclusion, there is a high correlation between import and export trade and patents.

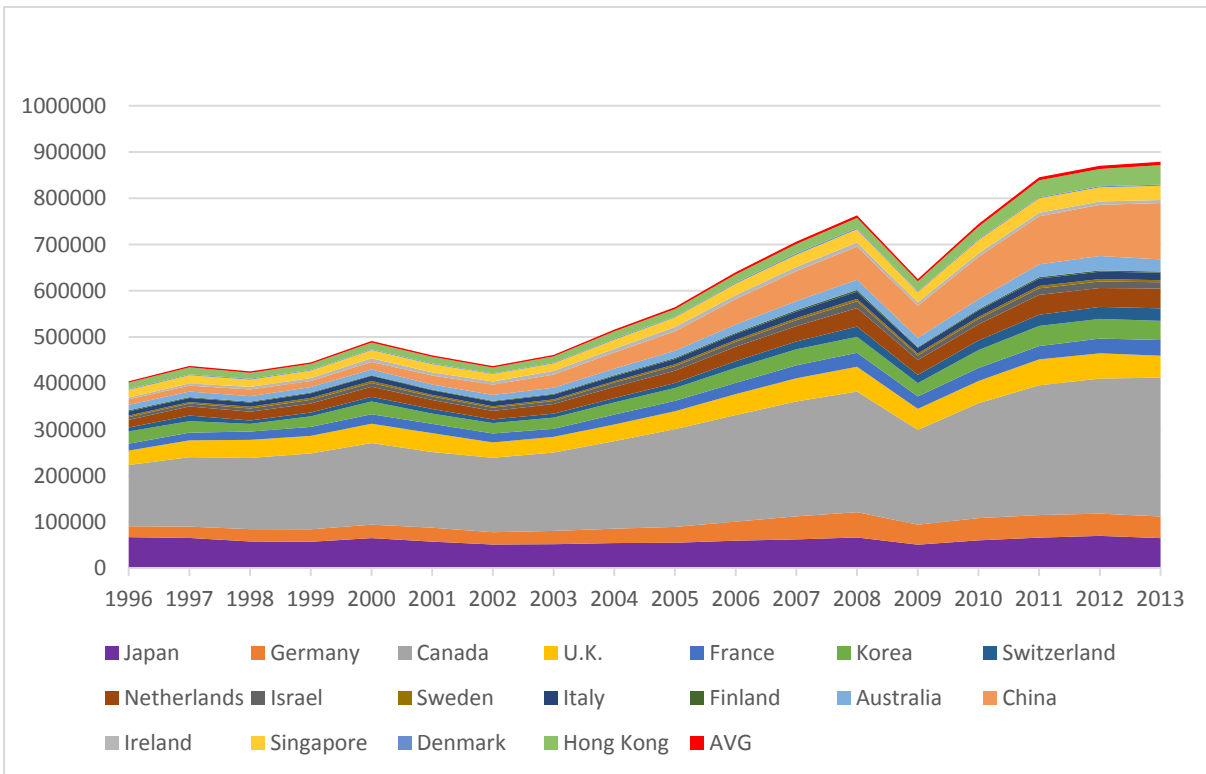


Fig. 3. USs' export performance (million) in seventeen nations and Hong Kong, 1996-2013
Source: UN-COMTRADE, own calculations.

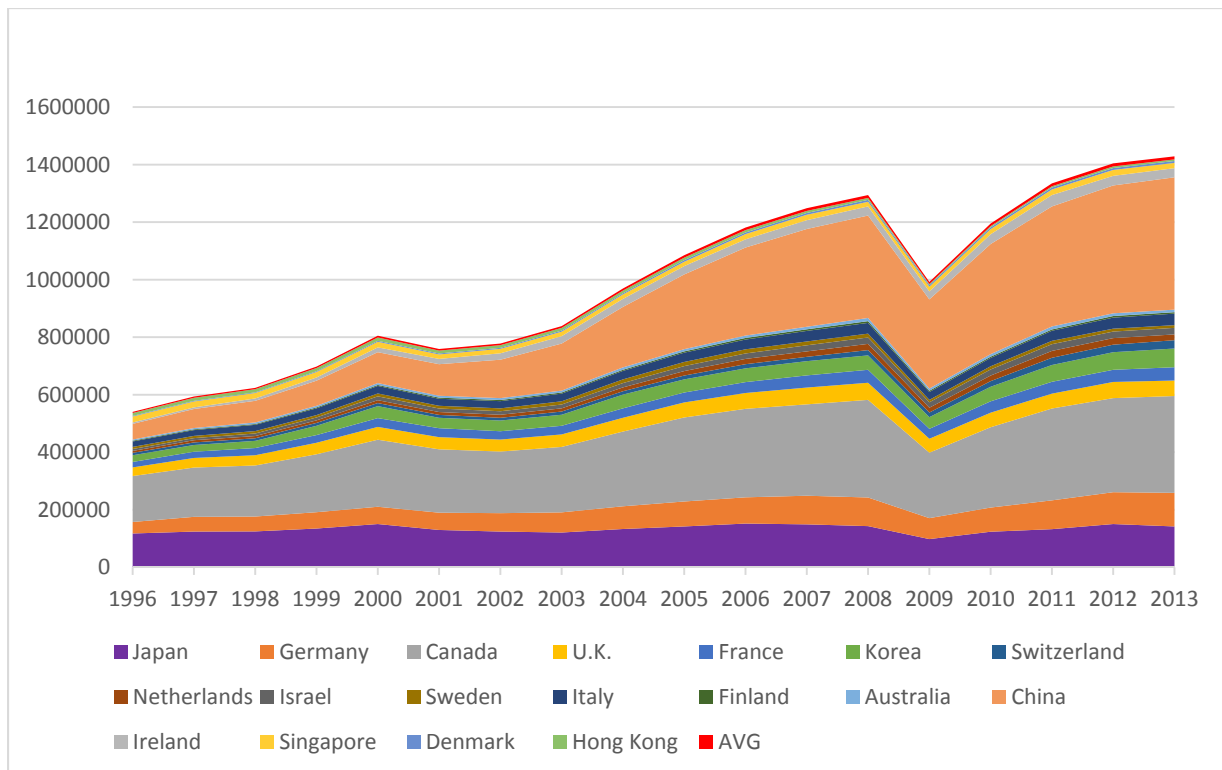


Fig. 4. USs' import performance (million) in seventeen nations and Hong Kong, 1996-2013
Source: UN-COMTRADE, own calculations.

TABLE 2. PEARSON PAIRWISE CORRELATION ANALYSIS FOR A SELECTED SET OF EXPORT & IMPORT PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 1996-2013 SOURCE: UN-COMTRADE, USPTO, OWN CALCULATIONS.

	US imports of the country	US exports of the country
Japan_C	0.331	-0.234
Germany_C	.850**	.813**
Canada_C	.798**	.896**
UK_C	.697**	.677**
France_C	.780**	.740**
Korea_C	.851**	.839**
Switzerland_C	.936**	.606**
Netherlands_C	.787**	.758**
Israel_C	.897**	.856**
Sweden_C	0.43	0.431
Italy_C	.643**	.653**
Finland_C	.736**	0.38
Australia_C	.843**	.891**
China_C	.895**	.966**
Ireland_C	.649**	0.125
Singapore_C	0.055	.943**
Denmark_C	.723**	0.269
Hong Kong_C	-.828**	.762**

*p < 0.10.

***p < 0.01: Significance level.

**p < 0.05: Significance level.

TABLE 3. THE REGRESSION COEFFICIENTS ANALYSIS FOR A SELECTED SET OF EXPORT & IMPORT PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 1996-2013 SOURCE: UN-COMTRADE, USPTO, OWN CALCULATIONS.

	US imports of the country	US exports of the country
Japan_C	.577**	-.512*
Germany_C	.598*	0.284
Canada_C	-0.399	1.272***
UK_C	0.431	0.335
France_C	0.799	-0.021
Korea_C	.495*	0.41
Switzerland_C	1.257***	-0.335
Netherlands_C	0.869	-0.084
Israel_C	.851**	0.049
Sweden_C	0.338	0.341
Italy_C	0.268	0.405
Finland_C	1.015***	-0.375
Australia_C	0.321	.620***
China_C	-.970***	1.912***
Ireland_C	1.286***	-.845***
Singapore_C	-0.128	.968***
Denmark_C	1.224***	-.661***
Hong Kong_C	-.596**	0.299

*p < 0.10.

***p < 0.01: Significance level.

**p < 0.05: Significance level.

Furthermore, in order to know whether the R&D performance has been indirectly effected we need to explore whether the patent has value or not, this paper used the information which from World Bank database (comprises a number of R&D and intellectual property fee[30]), then this paper chose the top seven ranking countries that cited US litigation patents using the years between 2005 and 2011. Then used these seven countries (Japan, Germany, Canada, United Kingdom, France, South Korea and United States) as the target countries then observed the annual growth rate with the United States in table 4 first.

The US biggest export trade partner has been Canada since 2005 in table 4. The trade volume between Canada and

US rapidly increased in recent decades, the US export trade to other countries has been non-volatile but has had slow upward growth since 2005. Obviously, Canada has a great impact on US export trade volume, and the trend is still increasing. According to the active global trade market, the average US export amount increased with slow growth rates year on year. This paper also observed the annual growth rate of trade with United States in table 5 which indicates the primary countries that US imported to with obviously higher trade values. US biggest import trade partner has been Canada since 2005. The trade volume between Canada and US has rapidly increased in the last decade.

TABLE 4. THE NUMBER OF ANNUAL GROWTH RATE THAT US EXPORTED TO COUNTRIES (THE NUMBER IN ROW TWO MEANS THE VOLUME (MILLION) AT THE YEAR 2005), 2005-2011 SOURCE: UN-COMTRADE, USPTO, OWN CALCULATIONS.

Export	Japan	Germany	Canada	UK	France	Korea
2005	55408.3	34141.1	211417.1	38621.4	22538	27670.3
2006	8%	21%	9%	18%	8%	17%
2007	5%	20%	8%	11%	14%	7%
2008	6%	10%	5%	7%	8%	0%
2009	-23%	-21%	-22%	-15%	-10%	-18%
2010	18%	11%	21%	6%	3%	36%
2011	9%	2%	13%	16%	4%	12%

TABLE 5. THE NUMBER OF ANNUAL GROWTH RATE THAT US IMPORTED TO COUNTRIES (THE NUMBER IN ROW TWO MEANS THE VOLUME (MILLION) AT THE YEAR 2005), 2005-2011 SOURCE: UN-COMTRADE, USPTO, OWN CALCULATIONS.

Import	Japan	Germany	Canada	UK	France	Korea
2005	141950.2	86934.0	291865.6	52368.7	34771.5	45522.8
2006	7%	5%	5%	4%	10%	5%
2007	-2%	9%	3%	6%	12%	4%
2008	-4%	0%	7%	3%	6%	1%
2009	-31%	-27%	-33%	-19%	-23%	-19%
2010	26%	16%	23%	5%	13%	25%
2011	7%	19%	14%	3%	4%	16%

After comparing table 4 and table 5, the US value of imports from Canada and exports to Canada was almost at the same rate, we can find that Canada is a very close trade partner of the US. The US import value from Germany increased over the years, if it follows this growth rate, Germany may have higher value than Japan after a few years. Since 2010, US imports more value amount from Korea than UK, it could be referred to the Korean economy growing rapidly in recent years.

Table 6 shows the mean and standard deviation source from R&D performance (researchers in R&D (per million people), charges for the use of IP-payment) and the number of countries annually citing litigation patents in US from seven countries (US, Japan, Germany, Canada, UK, France and Korea).

We can see the sharp drop in 2009 in both table 4 and table 5, according to the recession in the global market since 2008, after this crisis, both US import values and export values grew like in former years. This paper has also used the World Bank database to compare information of the relationship in those countries, because the World Bank

database is one of the most credible databases in the world. There has been a lot of information in this database, and this paper used two important parts of this database which are “Researchers in R&D” and “Charges for the use of IP (Intellectual Property), payment” respectively.

Fig. 5 illustrates the number of researchers in R&D. In Fig. 5, the horizontal axis shows the year from 2005 to 2011, while the vertical axis represents the quantity of researchers per million people. This chart shows the researcher quantity in Japan has maintained a high level of balanced development, yet, the researchers’ quantity in other countries (e.g. Germany, Canada, United Kingdom, France, Korea) have increased gradually from 2005, especially in South Korea. The total number of researchers in Korea had almost surpassed Japan in 2009, and have the largest number of researchers of all these countries. Overall, the quantity of researchers in these seven countries shows steady increase in Fig. 5. This shows that there is high demand for globalization and innovation, and means that these seven countries began to strengthen their investment in R&D.

TABLE 6. MEAN AND STANDARD DEVIATIONS FOR R&D PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 2005-2011 SOURCE: WORLD BANK, USPTO, OWN CALCULATIONS.

	Number of citing		Researchers in R&D		IP-payment(million)	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
US	18866.6	4088.7	3846.0	130.6	29335.9	3757.9
Japan	1842.6	190.2	5248.4	118.7	17131.3	1699.7
Germany	595.4	139.0	3649.2	314.6	12282.6	3014.2
Canada	421.9	99.6	4491.8	167.	8596.6	1287.3
UK	224.3	39.9	4125.2	50.6	9566.3	786.9
France	212.1	43.3	3628.9	226.4	6642.0	3267.0
Korea	331.6	108.7	4871.0	712.9	6216.3	1668.8

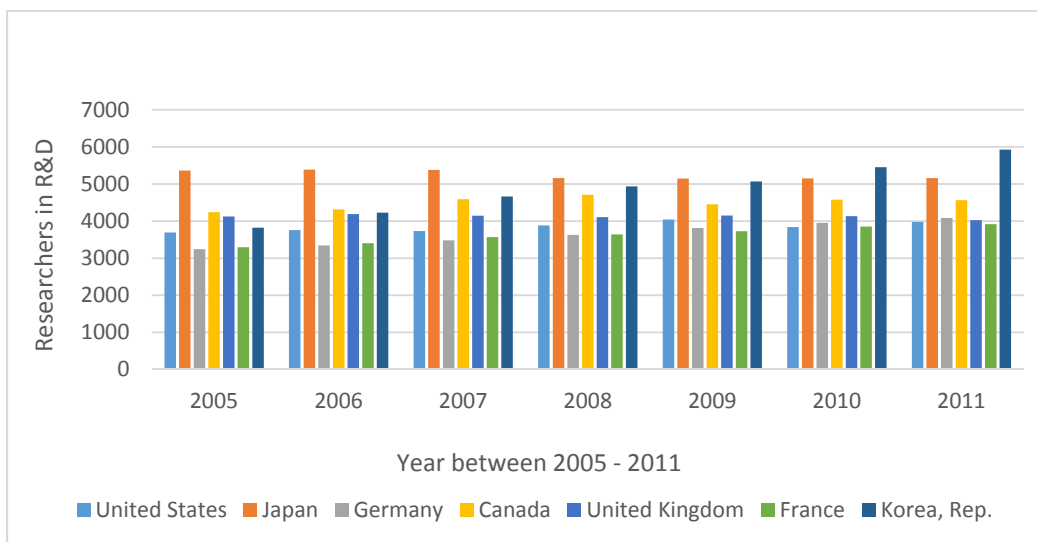


Fig. 5. Researchers in R&D (per million people), 2005-2011 Source: World Bank, own calculations.

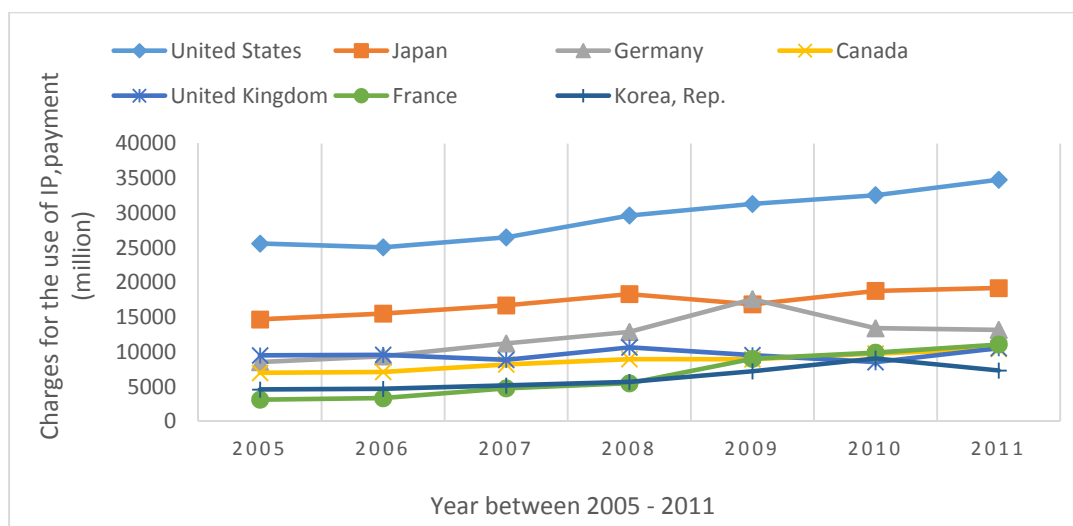


Fig. 6. Charges for the use of IP, payment (million), 2005-2011 Source: World Bank, own calculations.

Fig. 6 illustrates the charges for the use of IP payment. In Fig. 6, the horizontal axis shows the year from 2005 to 2011, while the vertical axis represents the charges for the use of IP payment (Bop, current US\$). The charges for the use of IP payment in US is much higher than in other countries (e.g. Japan, Germany, Canada, Korea, France, United Kingdom), and there is an increase in this cost every year. Although Japan is in second place out of these seven countries in 2008, Japan has been surpassed by Germany in 2009 and became number three. Other countries show a stable increasing trend. From looking at Fig. 5 and Fig. 6, Japan shows a high quantity of researchers and high charges for the use of IP payment. On the other hand, though the researchers in US are not as much as other countries, but the display of charges for the use of IP payment in US is the highest.

In addition, to understand whether there was a relationship

between R&D performance and patent value or not, this study analyses the correlation coefficient and uses multiple regression analysis in those countries (United States, Japan, Germany, Canada, Korea, France, United Kingdom) in table 7 and table 8. The main variables are R&D performance (researchers in R&D (per million people) and charges for the use of IP-payment). The result turns out that there is a significant relationship between countries annually citing litigation patents in the US and IP-payment in the US, Canada and South Korea. We also found that there are significant relationships between countries annually citing litigation patents in the US and researchers in R&D in Germany and Korea. This data all represents that R&D performance (researchers in R&D (per million people), that charge for the use of IP-payment) have the potential to explore the value of patents indirectly.

TABLE 7. PEARSON PAIRWISE CORRELATION ANALYSIS FOR R&D PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 2005-2011 SOURCE: WORLD BANK, USPTO, OWN CALCULATIONS.

	Researchers in R&D	IP-payment(million)
US_C	.439	.780*
Japan_C	.170	.208
Germany_C	.840*	.409
Canada_C	.460	.884**
UK_C	-.141	-.337
France_C	.484	.465
Korea_C	.910**	.971**

*p < 0.10.

***p < 0.01: Significance level.

**p < 0.05: Significance level.

TABLE 8. THE REGRESSION COEFFICIENTS ANALYSIS FOR R&D PERFORMANCE AND NUMBER OF COUNTRY ANNUALLY CITING LITIGATION PATENT IN US, 2005-2011 SOURCE: WORLD BANK, USPTO, OWN CALCULATIONS.

	Researchers in R&D	IP-payment(million)
US_C	-.562	1.235*
Japan_C	.988	1.009
Germany_C	1.175**	-.455
Canada_C	-.369	1.150**
UK_C	-.503	-.628
France_C	.463	.022
Korea_C	.341*	.689***

*p < 0.10.

***p < 0.01: Significance level.

**p < 0.05: Significance level.

We will begin our discussion by reviewing the empirical findings, and then turn to the general theoretical issues. These results may be explained by considering the globalized knowledge economy, because we are faced with the globalization of the trade environment in recent years. Accordingly, our analysis was designed to interpret the influence between intangible assets (litigation patents value) and tangible assets (international trade and R&D investment). Table 2 and table 7 shows that a more likely explanation rests in the nature of the flow of the knowledge economy, we interpret this to mean that the litigation patent is a valuable patent for forecasting the economy under certain conditions.

Our research suggests, albeit tentatively, two potentially important influences of the globalization of economic performance on the use of examining patent values, are international trade and R&D investment respectively. The results of this study partially support the notion that international trade and R&D performance has explanatory power in exploring patent value. Having acknowledged the limitations of the globalization performance observation data, we can nevertheless confirm that certain performance seems to have a particular set of structural features. Furthermore, patent value could probably estimate other tangible assets in the future.

V. CONCLUSION

This study shows that the relationship of US import and export performance is helpful for examining the value of litigation patents, and R&D performance (researchers in R&D (per million people), charges for the use of IP-payment)

can as an indirect measure examine patent value.[7] Through table 2, showing that there is a significant association between that countries citing US litigation patents and US cross-border trade data with those countries. Refers to Fig. 2, finds that prior ranking countries also had more active trade activity with US and the bottom ranking countries had less trade with the US. China however has a poor ranking[31], but the China cross-border trade volume with US was still enormous[32], it could represent the economic environment of China. In addition, table 7 interprets that the litigation patent value can be indirectly measured by R&D performance (researchers in R&D (per million people). Overall, citing the amount of US litigation patents can be used to explain whether the cross-border trade of one nation is active or not in this paper. (i.e., litigation patents are valuable for evaluating the performance of cross-border trade for one nation)

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