The Role of Foreign Patents in US Firms' Patent Portfolios

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The Role of Foreign Patents in US Firms' Patent Portfolios

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I investigate the role of foreign patents (patents issued in countries outside of the US) in US firms' patent portfolios. Foreign patents are substantial and prevalent for US firms. Foreign patents form about 39% of the average patent portfolio of US firms. Firms with foreign patent applications are financially stable, and these firms have a higher percentage of foreign sales to total sales. Besides, I exploit exogenous shocks to foreign sales (free trade agreements and bilateral investment treaties) to identify the effect of foreign sales on the propensity to foreign patent. I find firms with a larger percentage of foreign sales have a higher propensity to foreign patent. Additional analysis reveals US firms have a higher propensity to patent in countries with strong patent rights.

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Abstract

I investigate the role of foreign patents (patents issued in countries outside of the US) in US firms' patent portfolios. Foreign patents are substantial and prevalent for US firms. Foreign patents form about 39% of the average patent portfolio of US firms. Firms with foreign patent applications are financially stable, and these firms have a higher percentage of foreign sales to total sales. Besides, I exploit exogenous shocks to foreign sales (free trade agreements and bilateral investment treaties) to identify the effect of foreign sales on the propensity to foreign patent. I find firms with a larger percentage of foreign sales have a higher propensity to foreign patent. Additional analysis reveals US firms have a higher propensity to patent in countries with strong patent rights.

1 Introduction

The research question of this thesis is how do US firms protect their Intellectual Properties(IP) in foreign markets. The protection of IP is a crucial challenge that Multinational Enterprises (MNE) face in foreign markets(Somaya, 2012). The leakage of technological know-how could not only damage the potential rent that firms can extract from foreign markets but can also be detrimental to market shares in their home markets. For example, Radio Corporation of America (RCA) licensed their colour TV to Japanese firms in Japanese markets. These Japanese firms imitated the colour TV and entered into US markets with their imitated colour TV. Nowadays, Japanese firms are taking the largest market share in the US's colour TV market (Hill, Hwang & Kim, 1990). Identifying US firms' safeguards for their IP in foreign markets is an important yet insufficiently understood question.

Patents could be the first conventional safeguard of innovations that pops up to people's minds. Several survey-based studies (e.g. Levin, Klevorick, Nelson & Winter, 1987; Cohen, Nelson & Walsh, 2000) find that firms in most industries do not rely on patents. However, the number of patent applications has grown steadily all over the world since 2003 (WIPO, 2018). Besides, Kortum and Lerner (1998) find US patent applications have an unprecedented surge in the late 1990s; this unprecedented surge of US patent applications is not the result of expanded Research and Development (R&D) expenditures. If firms do not rely on patents, then why do firms patent aggressively? This thesis investigates this patent puzzle by studying the US firms' propensity to foreign patent.

Existing studies focus on US patents because patent data in the US is better than in other countries; the US historically has the largest total number of patent applications. However, the total number of Japanese patents (JP patents) applications surpassed the total number of US patent applications in 1970. Besides, Japanese Patent Office (JPO) is the patent office received most patent applications until 2005. Chinese Patent Office (CPO) has become the largest patent office since 2010 (WIPO, 2018). In addition, the World Intellectual Property Organization (WIPO) simplifies the procedure of foreign patenting in several countries simultaneously. Many Multinational Enterprises (MNE) in innovation-intensive industries intend to expand in foreign markets for amortization of R&D Costs (Kobrin, 1991; Tallman and Li, 1996). MNE can benefit from the services of WIPO because WIPO significantly reduces barriers to patent overseas. The existence of WIPO proves a high demand for foreign patents. Empirically, I find foreign patent applications comprise about

39% of the average patent portfolio of US firms. Therefore, foreign patents are as important as US patents. This thesis overcomes data limitations in foreign patent data and focuses on foreign patents.

To investigate reasons underpinning the existence of foreign patents, I employ a novel dataset that combines the information of US firms' patent applications and US firms' financial characteristics. First, this thesis investigates what kind of US firms patent abroad. Second, I study compositions of US firms' patent portfolios. Third, this thesis examines the relationship between foreign market activities and propensity to foreign patent. Lastly, I evaluate how the countries' strength of patent rights affect the US firms' propensity to foreign patent.

The novel dataset includes the patent applications information from Worldwide Patent Statistical Database (PATSTAT), US firms' financial characteristics from Compustat, Compustat segments, the foreign subsidiaries information in Exhibit 21 dataset and the strength of patent rights from Ginarte and Park (1997) and Park (2008). Besides, I compare financial characteristics between US firms with and without foreign patent applications to study what kind of US firms patent overseas. Firms with foreign patent applications are financially stable; have an outstanding accounting performance and market valuation; have a larger percentage of foreign sales to total sales. I construct patent portfolios for US firms from 1976 to 2012 to study compositions of patent portfolios. US firms increasingly emphasize foreign patents and have a higher propensity to patent in Europen Patent Office(EPO).

This thesis finds that US firms with a large percentage of foreign sales have a higher propensity to foreign patent. Ordinary Least Squares (OLS) regressions of the percentage of foreign patents on the percentage of foreign sales show a positive correlation between the percentage of foreign sales and the propensity to foreign patent. However, OLS regressions suffer from omitted variables issues. Patents are not the only appropriation mechanism for US firms in foreign markets. Firms could use alternative appropriation mechanisms such as trade secrets, leading time and complementary marketing capabilities to protect their IP in foreign markets. The existence of alternative appropriation mechanisms positively affect the percentage of foreign sales and negatively affect the propensity to foreign patent. Therefore, I exploit two Instrument Variables (IV) to address omitted variables issues, which are the US Free Trade Agreements (FTA) and US Bilateral Investment Treaties (BIT), respectively. FTA and BIT can reduce foreign market entry barriers for US firms and thus potentially enhance foreign sales. Also, FTA and BIT can only affect US firms' propensity to foreign patent through the channel of foreign sales. Therefore, FTA and BIT are valid IVs.

Two-Stage Least Squares (2SLS) regressions of the percentage of foreign patents on IVs shows a positive local average treatment effect between the propensity to foreign patent and the percentage of foreign sales. This positive local average treatment effect suggests that for firms that have foreign sales in FTA or BIT countries, firms with a larger percentage of foreign sales in the previous year are likely to have a higher propensity to foreign patent.

This thesis shows that US firms prefer to patent in countries with strong patent rights. OLS regressions of the percentage of foreign patents on the strength of patent rights find that the strength of a given country's patent right positively affects the propensity to patent in that country. Moreover, I run OLS regressions of the percentage of foreign patents on the average strength of patent rights, the percentage of foreign sales and the percentage of foreign capital expenditures. The result of regressions shows that foreign market activities and the strength of patent rights have more significant effects on the propensity to foreign patent.

Overall, I find that US firms use foreign patents to protect their IPs in foreign markets; The strength of a given country's patent right positively affect US firms' propensity to patent in that country. Previous studies primarily focus on US patents. This thesis investigates the role of foreign patents in US firms' patent portfolios and fills the research gap on studies of foreign patents. In addition, some studies investigate how does the change in a given county's patent law affect the propensity to domestic patent. This study focuses on the relationship between US firms' propensity to foreign patent and the strength of different countries' patent rights. Also, I find firms rely more on patents to protect product innovations in foreign market activities than process innovations in foreign production activities. This finding is consistent with survey-based studies (Cohen et al., 2000). Besides, existing studies heavily use US patent data, because patent data in the US is better than elsewhere, through the NBER-USPTO patent database. I create a method to match locations of patent offices and foreign business activities. This method potentially guides subsequent studies on foreign patents.

2 Literature Review and Hypothesis Development

Previous studies find contradictory evidence on studies of propensity to patent. Several survey-based studies (e.g. Levin et al., 1987 and Cohen et al., 2000) find that firms in most industries do not rely on patents. The contradictory evidence from quantitive studies shows US patent applications have an unprecedented surge that does not account for by the expanded investment in R&D

(Kortum and Lerner, 1998). Also, the number of patent applications are continuously increasing worldwide (WIPO, 2018). It is not surprising that survey-based studies find contradictory evidence against facts and quantitive studies because survey-based studies focus on the patent's efficiency of protecting innovations. Patents are not strong appropriation mechanisms in contrast to alternative appropriation mechanisms such as trade secrets, leading time, and complementary manufacturing capabilities because patents have limited life; patents application disclose full information about technology; The legal cost of patent infringement suits is expensive. However, patents are the only appropriation mechanism that have exclusive rights. The exclusive right endow strategic purposes to patents. Strategic purposes of patents ensure patents are irreplaceable by alternative appropriation mechanisms.

Given the importance of patents' strategic purposes, survey-based and qualitative studies start to investigate patents' strategic purpose. Survey-based studies find US firms exploit patents to block competitor's innovations, to improve bargaining power, to enhance the reputation of products and firms, to extract licensing profits, and to measure the R&D personnel (Cohen et al., 2000; Blind, Edler, Frietsch & Schmoch, 2006). Besides, firms could exploit patents to defend attacks from rival firms. For example, firms could rapidly apply for patents, when firms face risks being held up by competitors' patents. Therefore, the firms and rival firms' strategies can affect the propensity to patent. Also, firms' strategic objectives can predict the characteristics of firms' patents portfolios (Blind, Katrin & Elisabeth, 2009). Given that foreign patents comprise 39% of US firms' patent portfolios, it is interesting to investigate what is strategic purposes behind foreign patents in US firms' patent portfolios. Moreover, Survey-based studies find evidence about the strategic purpose of foreign patents. Arundel (2001) finds that firms exploit foreign patents to expand foreign markets. However, qualitative studies on the role of foreign patents are lacking.

Existing studies generally focus on US patents and ignore foreign patents (e.g. Pakes, 1986; Hall, Jaffe & Trajtenberg, 2001; Green and Scotchmer, 1995; Bessen and Maskin, 2009; Galasso and Schankerman, 2010; Conti, Thursby & Thursby, 2013; Kogan, Papanikolaou, Seru & Stoffman, 2017; Pakes, 1986). Patents are territorial rights. Different countries have different patentability. For example, the software is patentable in the US, but not in other countries. Different countries have different strength of patent rights (Ginarte and Park, 1997). Therefore, studies on US patents can not represent foreign patents. Given that the number of foreign patent applications is increasing, studies on foreign patents are important.

Existing studies focus on domestic patents. When firms have certain intangible assets that are

ready to make profits, firms tend to expand foreign markets by commercializing their intangible assets (Morck and Yeung, 1991). Large R&D costs force MNE to expand geographically as much as possible to maximize potential rents from innovations (Kobrin, 1991; Tallman and Li, 1996; Omae, 1985). Given that the US is technologically advanced firms (Eaton and Kortum, 1999), US firms are more likely to expand foreign markets. Therefore, it is important to investigate the relationship between the propensity to foreign patent and the foreign market activities.

Moreover, survey-based studies in Japanese patents find Japanese firms rank patents as the first appropriation mechanism(Cohen et al., 2002). The study in Japanese patents contradicts to the study in US patents. The contradicted evidence suggests that US firms could have a different propensity to patent in different countries. This study surpasses other studies by investigating how does the strength of patent rights in different countries affect the US firms' propensity to patent in different countries.

Survey-based studies show that one of the strategic purposes of patents is to expand foreign markets (e.g. Duguet and Kabla, 1998; Arundel, 2001), but the qualitative evidence is lacking to prove the belief of managers. The research on the entering mode of the foreign market is predominated by transaction cost theory (Williamson, 1975; Rugman, 1980). Local partners in foreign markets have a more significant incentive to act opportunistically and expropriate the MNE's innovations. The propensity of local partners to act opportunistically increase the dissemination risk of technological know-how that MNE must bear. Therefore, transaction costs theory suggests MNE tend to rely more on wholly-owned subsidiaries for commercializing sophisticated products in foreign markets because the wholly-owned subsidiaries can minimize the dissemination risk of technological know-how (Anderson and Gatignon, 1986). However, Kogut and Zander (1992) argue that MNE do not fail due to the opportunism of local partners, but due to the capabilities of taking advantages of MNE's technological know-how in the foreign market. Madhok (1997) argue that MNE should examine whether the reduction in transaction costs exceeds the bureaucratic costs of establishing the wholly-owned subsidiaries.

Moreover, the organizational capability theory suggests MNE face the difficulty that inefficient exploitation of technological know-how in the foreign market. The collaboration with local partners would help MNE to exploit capabilities entirely and are preferred at the early stage of entering foreign markets. However, Williamson (1985) shows that MNE commonly disclose some information about innovations to help local bidders to evaluate products. MNE bear the dissemination risk during the negotiation process. Patents are safeguards of innovation and disclose channel of infor-

mation. Patents can protect technological know-how and disclose information about innovations simultaneously. Patents cannot only protect MNE's innovations in foreign markets but also improve communication efficiency during the negotiation process. Besides, patents could also make economic profits of MNE and local partner at the same line. The dissemination risk of innovation shift from MNE to the local partner. The imitations in foreign markets are detrimental to the potential rent of local partners. Foreign patents could reduce the dissemination risk during the negotiation process, improve communication efficiency and prevent the local partners' opportunistic action. I argue that the functions of patents could help MNE in foreign markets.

Another strategic purpose of patents is to block competitors' innovations actively. Banbury and Mitchell (1995) find when new market entrant enter markets with innovations, market incumbents must improve their existing technology on time; otherwise, the new market entrant will attract all attentions from markets and steal the market shares from incumbents. For example, Apple enters into the telephone market with its patented touch-screen smartphone in 2007. Nokia resisted to adopt the new fashion of touch-screen smartphone and continuously introduced new phones with the keypad. Nokia eventually failed in the competition of the smartphone market. In addition, patents can be used to block market incumbents' follow-on innovations (Banbury and Mitchell, 1995). Foreign patents could increase the firms' competitiveness in foreign markets.

***Hypothesis 1*:**

Firms with foreign sales are more likely to apply for foreign patents.

The strength of patent rights could also affect the propensity to foreign patent. Strong patents rights are beneficial to the patentee. Hall and Ziedonis (2001) find the number of US patent applications has a dramatic increase after the US strengthen their patent law. Weak patent rights are detrimental to firms' benefits. The patent with a weak patent right cannot provide enough protection for innovations but disclose information as much as the patent with a strong patent right. For example, Novartis apply for the Indian patent for Gleevec, but India government reject Novartis's patent application. The Novartis won the Nobel prize with Gleevec, but Indian government rejected the patent application with a reason that is not novel enough (Novartis v. Union of India & Others). The decision of the Indian government results in that Novartis exit Indian markets. The Novartis's exit is not the end of the story. Indian government publish a patent application that includes know-how about Gleevec. Indian medicine manufacturing firms imitate and commercialize Gleevec in the Indian market. The imitated medicine industry is one of the largest industry in India. Arundel et al. (1995) conclude that different patents system and legislation could explain why firms have a different propensity to patent.

Hypothesis 2

US firms prefer to patent in countries with strong patent rights.

3 Data

This study uses different datasets to carry out empirical analysis. I use Compustat data for US firms' financial characteristics, PATSTAT for patents information, Compustat segments data for foreign sales and capital expenditure, E21 for foreign subsidiary information, and the strength of countries' patent rights from Ginarte and Park (1997) and Park (2008).

3.1 Identify Listed US Firms

I focus on US-listed firms in the Compustat-CRSP merged dataset (CCM). I retain only US firms that are listed in major stock exchanges, New York stock exchange, American stock exchange, NASDAQ Stock Market, Boston stock exchange, Pacific Exchange, and Philadelphia Exchange. I use Compustat variables that are Foreign Incorporation Codes (FIC) and current ISO countries code of headquarters to identify US-listed firms.

Our sample period is 1976 to 2012 because Compustat Segments dataset is available after 1976

and citations of the patent file after 2012 are affected by the truncation effect. The truncation effect is due to patents after 2012 do not have enough time to receive citations and the truncation effect results in fewer citations(Hall et al., 2001). I winsorize data at 1% and 99% level. After filtering, the sample includes 10,780 US firms and 125,603 observations from 1976 to 2012.

3.2 Description of Patent Data

I collect patent applications across countries from PATSTAT from 1976 to 2012. Following convention, I exclude utility model patent applications, plant patent applications, provisional patent applications and design patent applications. To combine the PATSTAT data into CCM dataset, I follow Koh et al. (2016)' method. I compare each assignee name in PATSTAT to company names in Compustat. If the assignee name in PATSTAT is close to a company name in Compustat according to Levenshtein distance, I substitute the Comupstat name for the assignee name. After matching, 3,889 US firms have patent applications and 6,891 US firms that do not have patent applications from 1976 to 2012.

3.3 Measuring Foreign Market Activities and Foreign Production Activities

I use the percentage of foreign sales to total sales as a measurement for foreign market business activities. A given firm has a non-zero percentage of foreign sales; suggesting that this firm present in foreign markets. Besides, the percentage of foreign sales also measure the importance of foreign markets. I collect foreign sales information from Compustat segments dataset. Variables geotp and snms in the Compustat segments can identify the location of segments. The Compustat segments dataset sometimes report segments data in the same year for three times, because firms' annual segment reports describe the most recent three years segment information. To removing duplicates in the dataset, I only retain the latest segment information. I find 4,192 US firms that report at least one foreign segment with non-zero sales during the sample period. 3,058 US firms do not have any segments information during the sample period.

I use the percentage of foreign subsidiaries' capital expenditures to total capital expenditures as the measurement for foreign production. Foreign subsidiaries information could misleadingly measure foreign production activities. For example, firms' foreign subsidiaries could be a business office. Therefore, I use both foreign capital expenditure information from the Compustat segment dataset and foreign subsidiaries information from Exhibit 21 dataset to capture foreign production activities. Exhibit 21 dataset provides locations of US firms' subsidiaries from 1994 to 2012. First, I

extract firms' capital expenditure information from Compustat segments dataset. Next, I manually match the location of foreign capital expenditure to foreign subsidiaries because location names in both of Compustat segments and Exhibit 21 dataset are not standardized.

3.4 Location Matching Between Foreign Patents and Foreign Business Activities

This section discusses the detailed process to match locations between foreign patents and business activities. Location names in Compustat segment dataset have 1783 non-standardized and distinct names, and thus the manually checking is required for some steps. The location matching between foreign business activities and patents has a more to more relationship because some patent offices can protect more than one regions; some regions are protected by more than one patent offices.

We start by discussing the cleaning process of Exhibit 21 dataset. The location name in Exhibit 21 includes country names or overseas dependent territories names. If foreign subsidiaries in Bermuda, Exhibit 21 will show the locations of foreign subsidiaries are Bermuda rather than the United Kingdom (UK). However, countries' patents can protect the intellectual properties in its overseas dependent territories. For example, UK patents can protect intellectual properties in Bermuda. Therefore, I substitute all overseas dependent territories into the sovereign states according to the protected areas of patents.

This section describes the cleaning process of location names in segments dataset. I match locations of business activities and foreign patents at the continent level. First, I transform upper case letters in location names into lower case letters, transform word groups into words, and correct the mis-spelling in words. For example, "Asia" become asia, "Europe, Canada, other foreign" become europe, canada, other and foreign, and "Euorpe" become europe. I only match the location of patent offices to four continents that are American and Caribbean, Asia and Pacific, Europe, and Africa because of data limitations. The principal of the matching is to change original locations names to these four regions. For these location names that cannot be categories into these four regions, I substitute these location names to value "none". For example, "Asia and Other foreign" will become "none", because "Asia and Other foreign" represent the business activities not only in Asia but also in the areas that I cannot define. Besides, this step requires manually checking because segments location names are not standardised. For example, if I use the computer to change all segment locations name with Asia to "Asia and Pacific", the computer will wrongly categories values like "Asian countries and foreign", "Asia and Canada", "World except for Asia", "China and Japan" and "Far East". Therefore, I manually clean location names in segments dataset,

and categories into five values that are "American and Caribbean", "Asia and Pacific", "Europe", "Africa", and "none".

This last step is to match the location of foreign business activities to foreign patent offices. If the business activity is conducted in territories of any regional patent offices such as EPO, Gulf Cooperation Council Patent Office (GCCPO) and African Regional Intellectual Property Organization (ARIPO), this location of business activities will match to both of regional and national patent. For example, European patents and UK patents will match to the business activities in the UK, because both EPO and the Intellectual Property Offices of the United Kingdom (GB) protect intellectual properties in the UK. If the location of business activities is in a region that is only protected by national offices, this location of business activities will match the national patent offices. For example, the business activities in Australia will only match to Australian patents.

4 Empirical Results

4.1 Descriptive Statistics

Table A1 describes variable definitions; table A2 reports summary statistics of sample firms. The sample includes 10,780 US-listed firms and 125,603 observations from 1976 to 2012. The average foreign sales of US-listed firms account for 10.50% of total sales. 51% of observations do not report R&D expenditures. For observations with R&D expenditure information, the average R&D expenditure is 7% of total assets in this sample. Besides, US-listed firms invest an average of 6% of total assets in capital expenditures. The average profitability of US-listed firms is excellent because the average Return on Assets(ROA) is 9% of total assets.

[Table A2]

4.2 Firms with and without Patent Applications

This section shows what kind of US firms have patent applications. Table 1 provides sample characteristics for firms with and without patent applications. 3,889 US-listed firms have patent applications during sample periods, which is group A in table 1. Overall, table 1 shows that firms with patent applications are financially stable; invest more in R&D expenditures; have outstanding stock market performances.

Firstly, firms with patent applications are financially strong firms. The size, Log of Book Values

(log (BV)) and cash of group A are statistically significantly larger than group B. Also, group A firms have fewer debts than group B. Secondly, firms with patent applications invest more in R&D and capital expenditures and are likely to report R&D expenditures. Group A has statistically significantly larger R&D and capital expenditures. Besides, only 36% of group A does not report R&D. On average, firms with patent applications are not as profitable as firms without patent applications. However, firms with patent applications outperform firms without patent applications in stock markets. Group A has a smaller ROA but a larger Log of Market Values (log (MV)), Market to Book Value Ratio (MB), Tobins'q and annual return than group B. Lastly, firms with patent applications are in market concentrated industries. Group A firms are operating in industries with a larger average Herfindahl-Hirschman Index (HHI) than group B.

[Table 1]

4.3 Firms with and without Foreign Patent Applications

This section shows the financial characteristics of firms with and without foreign patent applications. For firms that have patent applications, 78% of these firms field foreign patents, which is group A in table 2. Firms with foreign patent applications are financially stable, have a higher percentage of foreign sales.

Table 2 shows that firms in group A have a larger size, log (MV), log (BV), MB and smaller leverage, suggesting that firms with foreign patent applications are financially stronger than firms without foreign patent applications. Interestingly, firms in both groups invest the same amount of R&D and capital expenditures, but firms without foreign applications are more profitable than firms with foreign patent applications. Firms in group A have smaller ROA than firms in group B. R&D and capital expenditures of both groups are not statistically significantly different. Also, group A firms have a more substantial percentage of foreign sales. The average percentage of foreign sales for group A is 22.68%, but group B only has an average foreign sales of 11.83% of total sales.

[Table 2]

4.4 Compositions of Patent Portfolios

This section describes compositions of US firms' patent portfolios. US firms have a substantial amount of foreign patent applications in their patent portfolios. Panel A shows that foreign patent applications account for an average of 39.19% of patent portfolios. Besides, US firms file most

considerable number of European Patents (EP patents) except for US patents, which account for an average of 10.7% of patent portfolios. US firms file a substantial amount of Germany Patents (DE patents), Canadian Patents (CA patents) and Chinese Patent (CN patents) applications, which is an average of 4.68%, 3.35% and 1.44% of patent portfolios, respectively.

Panel B to C of table 3 describes adjusted patent citations(Hall et al., 2001) of US firms' patent portfolios. Panel B shows that a patent from a given US firm make an average of 1.97 adjusted citations. A given US firm make an average of 887.61 adjusted citations from 1976 to 2012. Panel C finds that 4.11% of total backward adjusted citations are self-citations.

Panel D and E describes the popularity of cited authorities. I classify EE patents in panel D and E as a combination of EP patents and patents from national patent offices except for UK patent offices in European Union Countries. In panel D, I focus on authorities of patents that are cited by patents of US firms. The citing patents of US firms could be US firms' patents from any patent offices. For example, the citing patent could be US firms' JP, DE or EP patents. Panel D finds US firms mostly cite US patents, which is an average of 92.70% of total backward citations. Besides, EP and EE patent also receive a large number of backward citations from US firms. Interestingly, US firms do not have a substantial amount of JP patents, but JP patents receive a third large number of backward citations from US firms, which account for 1.17% of total backward citations.

Panel E focuses on patent authorities that are cited by US patents of US firms. US patents still account for a large part of total backward citations, which is an average of 92.36% of total backward citations. Also, JP patents and EP patents account for a nearly equal percentage of total backward citations made by US patents from US firms. The evidence from panel E and D shows that JP patents draw more US firms' attention than other patents, and this evidence is consistent with Eaton and Kortum (1999)'s findings.

Panel F constructs the generality and originality measurement(Trajtenberg et al., 1997) from patents from US firms. I find the average generality of patents for a given US firm is 0.34 and the average originality of patents for a given US firm is 0.35.

[Table 3]

4.5 Firms with and without Foreign Segments

Table 4 shows that firms' characteristics for firms with and without foreign segments. I define foreign segments as segments with non-zero sales that are located outside of the US. I find that

28.37% of US firms do not have segments information. 38.89% of US firms have foreign segments, which is group A of table 4. Overall, firms with foreign segments are financially stable; have a substantial amount of R&D expenditure; have a larger percentage of foreign patent applications to total patent applications.

First, firms with foreign segments are financially stable firms because firms in group A have a larger average size, log (BV), PPE, cash and smaller leverage than firms in group B. Moreover, firms with foreign segments are more profitable and have better stock performance than firms without foreign segments. Firms in group A have a larger log (MV), MB, ROA and annual return than firms in group B. Also, firms with foreign segments invest more in R&D expenditures and prefer to report R&D expenditures. Firms in group A invest 5% of total assets in R&D expenditures, but firms in group B only invest 2% of total assets in R&D expenditures. In addition, foreign patents take a substantial share of patents portfolios in firms with foreign segments. The average percentage of foreign patents in the patent portfolio is an average of 16.34% of patent portfolios for firms in group A, but an average of 3.64% of patent portfolios for firms in group B.

[Table 4]

4.6 Firms with and without Foreign Subsidiaries

Table 5 describes firm characteristics for firms with and without foreign subsidiaries. Table 5 exploits the sample from 1994 to 2012 because Exhibit 21 dataset only provides subsidiaries information from 1994. 40.81% of US firms have foreign subsidiaries, which is firms in group A of table 5. 20.92% of US firms do not have subsidiaries information. Overall, firms with foreign subsidiaries are financially stable firms with a large percentage of foreign sales and foreign patents. Besides table 5 has the most significant differences in most financial characteristics and stock market performances between firms in group A and B in contrast to previous tables.

Firms with foreign subsidiaries are financially stronger than firms without foreign subsidiaries. Firms in group A have statistically significantly larger size, log (MV), log (BV), MB and cash than firms in group B. In addition, firms in group A outperform firms in group B in the stock market. The annual return is 18% for firms in group A and 15% for firms in group B. Besides, firms with foreign subsidiaries have a larger average of foreign sales to total sales. Group A ' foreign sale is an average of 21.62% of total sales, but group B' foreign sale is only an average of 3.47% of total sales. Also, firms with foreign subsidiaries have a substantial amount of foreign patents in their patent

portfolios. The average percentage of foreign patents in the patent portfolio is an average of 17.28% of patent portfolios for firms in group A, but an average of 5.60% of patent portfolios for firms in group B.

Compare table 5 to previous tables, and I find differences in size, log(MV), log(BV), MB, ROA, annual return, PPE between group A and B are more significant than differences of these variables in previous tables. However, the difference in R&D expenditures is smallest in contrast to previous tables.

[Table 5]

4.7 Foreign Patents and Foreign Sales: OLS Estimates

To evaluate the relationship between firms' foreign market activities and propensity to foreign patent, I run OLS regressions of the percentage of foreign patents on the percentage of foreign sales, which is regressions one. The percentage of foreign sales is a measurement for foreign market activities. A given firm with a non-zero percentage of foreign sales represents that this firm present in foreign markets. Besides, the percentage of foreign sales can also measure the importance of foreign markets. Moreover, I use the percentage of foreign patents to measure US firms' propensity to foreign patent. A given firm with a large percentage of foreign patents represents this firm has a higher propensity to foreign patent.

$$\%\text{Foreign Patents}_{i,t} = \beta_0 + \beta_1 \%\text{Foreign Sales}_{i,t-1} + \beta_i X_{i,t-1} + e_{i,t-1}. \quad (1)$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

[Table 6]

Table 6 shows the results of OLS regressions. Both of column 1 and 2 run regressions one. Column 1 adds the industry and year fixed effects, and standard errors of column 1 are clustered at the industry level. Column 2 adds the firm and year fixed effect, and standard errors of column 2 are clustered at the firm level. Column 1 and 2 display coefficients of the percentage of foreign sales

(β_1) is economically and statistically significant from zero, suggesting that the firms' percentage of foreign sales is positively correlated with the percentage of foreign patents.

%foreign sales variable could lead to different interpretation. Patents are territorial rights, and thus firms' foreign patents in a given location can only affect firms' foreign market activities in that location. For example, JP patents can only protect patentee's innovation inside of Japan, and firms' JP patents could only affect firms' market activities in Japan. Therefore, I match locations of foreign sales to foreign patents and create two variables called the percentage of matched foreign sales and the percentage of matched foreign patents. I run OLS regressions of the %matched foreign patents on %matched foreign sales in the panel dataset with the firm, year and location dimensions, which is regression two. Column 3 add the year and industry fixed effects, and standard errors of column 3 are clustered at the industry level. Column 4 add the year and industry fixed effects, and standard errors of column 4 are clustered at the industry level. The coefficient of %matched foreign sales is economically and statistically different from 0 in column 3 and 4, suggesting %matched foreign sales is positively correlated with %matched foreign patents.

$$\%\text{Matched Foreign Patents}_{i,j,t} = \beta_0 + \beta_1 \%\text{Matched Foreign Sales}_{i,j,t-1} + \beta_i X_{i,j,t-1} + e_{i,j,t-1} \quad (2)$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

The question should be how to interpret this relationship. Regressions one and two potentially suffer from omitted variables issues. Patents are not the only appropriation mechanism. Firms can use alternative appropriation mechanisms such as trade secrets, leading time and complementary manufacturing and marketing capabilities. Alternative appropriation mechanisms are impossible to measure. The existence of alternative appropriation mechanisms could be positively correlated with %(matched) foreign sales in regressions one and two. For example, a US firm could use trade secrets to protect their innovations in foreign markets. Trade secrets could ensure US firms continuously present in foreign markets. Also, the existence of alternative appropriation mechanisms could be negatively correlated with %(matched) foreign patents in regressions one and two. For example, if a firm use trade secrets to protect their innovations, this firm will have a lower propensity to patent. Trade secrets and patents are mutually exclusive because patent applications disclose innovations' technological know-how.

The existence of alternative appropriation mechanisms is positively correlated to %foreign sales; is negatively correlated to %foreign patents. Therefore, regressions 1 and 2 potentially suffer from omitted variables issues. I use Instrument Variables(IV) to resolve omitted variables issues in regressions 1 and 2.

4.8 Foreign Patents and Foreign Sales: 2SLS Estimates

This section explains economic arguments that support the validity of IVs. IVs are the Free Trade Agreement (FTA) dummy, FTA cumulative dummy (FTA cum dummy), Bilateral Investment Treaty (BIT) dummy and BIT cumulative dummy (BIT cum dummy).

4.8.1 FTA dummy and FTA cumulative dummy

FTA dummy is a dummy variable that is 1 if firms have foreign segments in countries that have FTA with the US and otherwise zero. FTA cumulative dummy is the number of foreign segments in countries that have FTA with the US. For example, if US firms reported foreign sales in China in 2000 and Canada and Australia in 2008, FTA dummy will be 0 in 2000. FTA cumulative dummy will 0 in 2000. FTA dummy will be 1 in 2008. FTA cumulative dummy will be 2 in 2008.

FTA is an agreement that can expand the investment and trade opportunities between the US and other states (International Trade Administration, 2019). Therefore, FTA could reduce US firms to entry barriers in member states' market, and result in higher foreign sales in member countries. Besides, the first stage regressions in table 7 and 9 show that coefficients of IVs are economically and statistically significant from zero. The F-statistic of table 7 and 9 furtherly shows that IV variables are significantly different from 0. Therefore, IV variables conform to the relevance condition of IV. Moreover, the primary purpose of FTA is to reduce trading barriers for US firms. FTA agreements are not likely to be correlated with omitted variables in regressions one and two. FTA and FTA cumulative dummy conform to exclusion restriction. FTA dummy and cumulative dummy can only affect the propensity to foreign patent through %foreign sales. Therefore, FTA and FTA dummy are valid IVs.

4.8.2 BIT dummy and BIT cumulative dummy

The section examines the validity of BIT dummy and BIT cum dummy as IVs. BIT dummy is a dummy variable that is 1 if firms report foreign sales in countries that have BIT with the US. BIT cumulative dummy is the number of foreign segments in countries that have BIT with the US. BIT

aims to protect the investors' rights and ensure US investors who are treated in a non-discriminatory way (Office of the U.S. Trade Representative, 2019). Therefore, BIT encourages US firms to invest in countries that have BIT with the US. BIT positively affect foreign sales in these countries. The first stage regressions in table 8 and 9 show coefficients of BIT and BIT cumulative dummy are statistically significant from zero. F-statistics in first stage regressions shows the BIT and BIT cumulative dummy are statistically significant from zero. Besides, BIT and BIT cumulative dummy are not likely to be correlated with omitted variables in regressions one and two. Therefore, BIT and BIT cumulative dummy conform to the exclusion restriction and relevance condition.

4.8.3 2SLS Regressions Results

This section describes 2 SLS regressions results in table 7 and 8. I add industry and year fixed effects in 2SLS regressions and cluster standard errors at the industry level.

In table 7, columns 1 and 3 show the first stage regressions with FTA and FTA cum dummy, which is regression three. Columns 2 and 4 show the second stage regressions with FTA and FTA cum dummy, which is regression four. Table 7 finds coefficients of $\%\widehat{\text{Foreign}}\text{ sales}_{it-1}$ are statistically and economically significant from zero, suggesting that there is positively local average treatment effect between %foreign sales and %foreign patents. This local average treatment effect represents that for subsample that only includes firms have foreign sales in FTA countries, the higher percentage of foreign sales in last year results in a higher percentage of foreign patents in the current year.

[Table 7]

Table 8 shows the 2 SLS regressions results with BIT and BIT cum dummy. $\%\widehat{\text{Foreign}}\text{ sales}_{it-1}$ in table 8 are estimated by BIT in column 1 and BIT cum dummy in column 3. Columns 2 and 4 shows coefficients of $\%\widehat{\text{Foreign}}\text{ sales}_{it-1}$ are statistically and economically significant from zero; suggesting that for these firms who have foreign segments in BIT countries, firms with a higher percentage of foreign sales in last year are likely to emphasize more on foreign patents in the current year.

$$\%\text{Foreign Sales}_{i,t-1} = \beta_0 + \beta_1 IV_{i,t-1} + \beta_i X_{i,t-1} + e_{i,t-1} \tag{3}$$

$$\%\text{Foreign Patents}_{i,t} = \beta_0 + \beta_1 \%\widehat{\text{Foreign}}\text{Sales}_{i,t-1} + \beta_i X_{i,t-1} + e_{i,t-1} \tag{4}$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D

report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

[Table 8]

The question here should be whether the local average treatment effect is significant enough to represent the whole sample. In 2015, 47% of US goods exports went to FTA partner countries. FTA and BIT countries cover both developed and developing countries from all continents. Therefore, I argue that the local average treatment effect has significant explanatory power to the average treatment effect.

Next, I run 2SLS regressions of %matched foreign patents on IVs in the panel dataset with the firm, year and location dimensions. Regressions 5 and 6 are the first and second stage regressions. Regression 5 and 6 add industry and year fixed effect and cluster the standard errors at the industry level. Table 9 shows coefficients of FTA and FTA cum dummy are not statistically significant. The possible reason could be FTA and FTA cum dummy have limited explanatory power to %matched foreign sales. Economic magnitudes and t-statistics for FTA and FTA cum dummy in first stage regressions in table 9 are smaller in contrast to table 7. The reduced t-statistics could mean the matching process between locations of foreign sales and patent offices reduce the explanatory power of FTA and FTA cum dummy. The reduced explanatory power of FTA and FTA cum dummy is due to data limitations in Compustat segments dataset. Compustat segments dataset provide unstandardized location names, the process of matching from locations of business activities to patent offices are not perfect.

[Table 9]

Moreover, the economic magnitude and t-statistics of BIT cum dummy in table 9 have an increase in contrast to table 8; suggesting that the BIT cum dummy can explain the %matched foreign sales as well as %foreign sales. The coefficient of BIT cum dummy in table 9 is statistically and economically significant from zero. This result suggests that for firms have foreign sales in BIT countries, a higher percentage of foreign sales in BIT countries in the previous year results in a higher propensity to patent in the location of foreign sales.

$$\%\text{Matched Foreign Sales}_{i,j,t-1} = \beta_0 + \beta_1 IV_{i,j,t-1} + \beta_i X_{i,j,t-1} + e_{i,j,t-1} \quad (5)$$

$$\%\text{Matched Foreign Patents}_{i,j,t} = \beta_0 + \beta_1 \%\widehat{\text{Matched Foreign Sales}}_{i,j,t-1} + \beta_i X_{i,j,t-1} + e_{i,j,t-1} \quad (6)$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

In table 10, I run 2SLS regressions of %foreign patents on $\%\widehat{\text{ForeignSales}}_{(t-1)}$ with instruments variabl sFTA and BIT cum dummy. Column 1 and 2 of table 10 include year and firm fixed effects; standard errors are clustered at the firm level. Column 3 and 4 of table 10 include year and industry fixed effects; standard errors are clustered at the industry level. Hansen J statistic suggest both IVs are valid.

Table 10 finds coefficients of $\%\widehat{\text{ForeignSales}}_{(t-1)}$ are statistically and economically significant from zero, suggesting that there are positively local average treatment effect between %foreign sales and %foreign patents. This local average treatment effect represents that for subsample that only includes firms have foreign sales in FTA or BIT countries, the higher percentage of foreign sales in last year results in a higher percentage of foreign patents in the current year.

[Table 10]

$$\%\text{Foreign Sales}_{i,t-1} = \beta_0 + \beta_1 \text{FTA}_{i,t-1} + \beta_1 \text{BIT cum dummy}_{i,t-1} + \beta_i X_{i,t-1} + e_{i,t-1} \tag{7}$$

$$\%\text{Foreign Patents}_{i,t} = \beta_0 + \beta_1 \%\widehat{\text{Matched Foreign Sales}}_{i,t-1} + \beta_i X_{i,j,t-1} + e_{i,t-1} \tag{8}$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

Overall, the evidence in this section implies that firms with a higher %foreign sales in the previous year commonly apply for more foreign patents in the current year. This finding is robust to eliminating omitted variables issues. Therefore, US firms use foreign patents to protect their IP in foreign markets.

4.9 Strength of Patent Rights

This section evaluates how the strength of countries' patent rights affect the US firms' propensity to foreign patent. I use Ginarte and Park (1997) and Park (2008)'s measurement to measure the

strength of countries' patent rights.

4.9.1 Strength of Countries' Patent Rights and Propensity to Foreign Patent

This section describes how does the strength of countries' patent rights affect US firms' propensity to foreign patent. I run OLS regressions of %foreign patents on the strength of patent rights in the panel dataset with the firm, year and patent offices dimensions, which is regression seven. Column 1 in table 10 includes industry and year fixed effects, and standard errors are clustered at the industry level. The coefficient of the lagged strength of patent right is statistically and economically significant from zero, suggesting that the strength of a given country' patent right positively affect the propensity to patent in this country. Overall, US firms rely more on foreign patents in countries that have a stronger patent right.

$$\%\text{Foreign Patents}_{i,j,t} = \beta_0 + \beta_1 \text{Strength of Patent Right}_{i,j,t-1} + \beta_i X_{i,j,t-1} + e_{i,j,t-1} \tag{9}$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

[Table 11]

4.9.2 Strength of Countries' Patent Rights, Foreign Market and Foreign Production

Foreign market activities, foreign production activities and the strength of countries' patent rights could affect the propensity to foreign patent. I run OLS regressions of %foreign patents on %foreign sales, %foreign capex and the average strength of patent rights to evaluate which effect is more significant. In regression eight, I use %foreign sales and %foreign capex to measure foreign market activities and foreign production activities, respectively. Besides, the average strength of countries' patent rights is the average patent rights score of patent offices. For example, a given firm file JP and DE patents in 2008, the average strength of patent rights should be the average patent rights score of JP and DE patents in 2008. Regression eight includes the industry and year fixed effects. Standard errors are clustered at the industry level.

$$\begin{aligned}\%\text{Foreign Patents}_{i,t} = \beta_0 + \beta_1 \text{Average Strength of Patent Right}_{i,t-1} + \\ \beta_2 \%\text{Foreign Sales}_{i,t-1} + \beta_3 \%\text{Foreign Capex}_{i,t-1} + \beta_i X_{i,t-1} + e_{i,t-1}\end{aligned} \tag{10}$$

X is a vector of control variables that includes: size, leverage, the Return of Asset (ROA), Asset Growth Rate (AGR), Free Cash Flow (FCF), Cash, Research and Development cost (R&D), R&D report dummy, Capital Expenditure (Capex), Plant, Property and Equipment (PPE), Sale Growth rate (SGR), Annual return, Tobin's q, ln (Market value) and Herfindahl-Hirschman Index (HHI).

Column 2 of table 10 shows the average strength of patent rights and %foreign sales have statistically significant and positive coefficients. This result suggests that the strength of countries' patent rights and foreign market activities have more significant effects on US firms' propensity to foreign patents. Foreign production activities have an insignificant effect in contrast to foreign market activities and the strength of patent rights.

4.10 Event study: the relationship between foreign market entry and number of foreign patents

Figure 1 shows the change in the number of foreign patents before and after foreign market entry. The x-axis represents how many years before or after the foreign market entry. 0 in x-axis represents the time of foreign market entry. Figure 1 find firms have a higher propensity to foreign patent two years before foreign market entry. This result suggests when US firms plan to enter into a new foreign market, US firms are more likely to apply for foreign patents in their target countries.

2SLS and OLS regression of the percentage of foreign sales and foreign patents find US firms with foreign market have a higher propensity to foreign patent. Event study shows US firms are likely to apply for foreign patents two years before foreign market entry. These results jointly prove that US firms use foreign patents to protect their innovations in foreign markets. Also, foreign patents could help US firms to penetrate the foreign markets. The 2SLS regression and event study shows the importance of foreign patents.

Moreover, US firms face technology leakage risk in foreign markets. Patents in countries that have weak IP protection amplify this risk. An important function of patents is to promote technology diffusion because patent offices publish technological know-how of patent applications. Weak patents cannot provide enough protection for innovations, but these weak patents disclose as much information as strong patents disclose.

US firms have to make a trade-off between pursuing innovation protection and avoiding technology leakage from weak patent applications. The OL regression of %foreign patents on the strength of IP protection shows US firms are more likely to apply for patents. Therefore, US firms rely more on patents in countries that have stronger IP protection. US firms rather choose not to patent in

countries with weak IP protection because weak patents potentially amplify the risk of technology leakage.

5 Conclusions

In this thesis, I find that US firms use foreign patents to protect their IP in foreign markets; US firms prefer to patent in countries with strong patent rights. First, I find firms with foreign patent are financially stable; have superior accounting performance and market valuations; have a substantial percentage of foreign sales to total sales. Besides, OLS regressions of % (matched) foreign patents on % (matched) foreign sales show that the percentage of foreign sales is positively correlated with the percentage of foreign patents. Next, 2SLS regressions of %foreign patents on %foreign sales find that for those firms that have foreign sales in FTA or BIT countries, a more significant percentage of foreign sales in the previous year result in a higher propensity to foreign patent in the current year. In addition, 2SLS regressions of %matched foreign patents on %matched foreign sales find that for those firms that have foreign sales in BIT countries, a higher percentage of foreign sales in BIT countries in the previous year will result in a higher propensity to patent in the location of foreign sales. Moreover, OLS regressions of %foreign patents on the strength of countries' patent rights. I find firms prefer to file patents in countries with strong patent rights. Last but not least, OLS regressions of %foreign patents on %foreign sales, %foreign capital expenditure and the strength of countries' patent rights find that foreign market activities and the strength of countries' patent rights have significant effects; foreign productions have insignificant effects on the propensity to foreign patents.

This thesis has implications for the literature on patents. In particular, previous studies focus on US patents and lack studies on foreign patents. This thesis fills this gap by investigating the relationship between the percentage of foreign sales and propensity to foreign patent. In addition, existing studies investigate how does the strength of domestic patent rights affect the firms' propensity to domestic patents. However, this thesis focuses on the relationship between the strength of foreign countries' patent rights and the US firms' propensity to foreign patent. Also, this thesis finds that foreign production activities have an insignificant effect on the propensity to foreign patent. This finding is consistent with the previous survey-based studies (Cohen et al., 2000). Besides, this thesis creates a method to match locations of foreign sales and foreign patents. The matching method overcomes the essential difficulty on studies of foreign patents. This matching method potentially

guides future studies of foreign patents.

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Table 1
Firms with and without patent applications

The table presents the sample characteristics for firms with and without patent applications. The sample consist of 10,780 US firms in the Compustat and CRSP merged dataset from 1976 to 2012. The patent application information is from the PATSTAT. Continuous variables, except state-level variables, are winsorized at their 1st and 99th percentiles. *Mean* is the average, *St. dev.* is the standard deviation, *Diff.* is the mean difference between firms with and without patent applications (A-B), *t-stat.* is the t-statistic for the difference in means, and *p-val.* is the p-value associated with the t-statistics on the difference in means. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively. Variables definitions are provided in table A 1 in Appendix.

	With patents (A)		No patents (B)		t-stat. (A-B)		
	Mean	St. dev.	Mean	St. dev.	Diff.	t-stat.	p-val.
Size	5.73	2.21	5.62	1.99	0.11	9.5***	0.00
Log (MV)	5.69	2.11	4.83	1.86	0.86	76.4***	0.00
Log (BV)	4.95	2.02	4.40	1.74	0.54	50.27***	0.00
MB	2.91	3.60	2.08	2.78	0.83	45.65***	0.00
Leverage	0.20	0.19	0.25	0.22	-0.05	-41.37***	0.00
Asset growth ratio	0.15	0.37	0.16	0.34	-0.01	-2.51***	0.01
R&D	0.06	0.11	0.01	0.04	0.05	104.1***	0.00
Not report R&D dummy	0.36	0.48	0.67	0.47	-0.32	-119.23***	0.00
Capital expenditure	0.06	0.05	0.05	0.07	0.00	5.02***	0.00
Return on asset	0.09	0.18	0.09	0.12	0.00	-5.84***	0.00
Cash	0.19	0.23	0.11	0.15	0.08	75.94***	0.00
Dividend	0.01	0.02	0.01	0.03	0.00	-8.87***	0.00
Tobins'q	2.05	1.67	1.50	1.17	0.54	66.98***	0.00
Sales growth ratio	0.17	0.41	0.17	0.38	0.00	1.01	0.31
Free cash flow	-0.02	0.15	-0.02	0.11	0.00	-3.75***	0.00
PPE	0.26	0.21	0.26	0.28	0.00	-1.86*	0.06
Annual return	0.19	0.62	0.18	0.55	0.01	3.71***	0.00
HHI	0.52	0.34	0.42	0.35	0.10	52.2***	0.00
Observations	63,478		62,125				

Table 2
Firms with and without Foreign Patent Applications

The table present sample characteristics between firms with and without foreign patents applications. Continuous variables, except state-level variables, are winsorized at their 1st and 99th percentiles.*Mean* is the average, *St. dev.* is the standard deviation, *Diff.* is the mean difference between firms with and without patent applications (A-B), *t-stat.* is the t-statistic for the difference in means, and *p-val.* is the p-value associated with the t-statistics on the difference in means. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively. Variables definitions are provided in table A 1 in Appendix.

	With foreign patents (A)		No foreign patents (B)		t-test (A-B)		
	Mean	St. dev.	Mean	St. dev.	Diff.	t-stat.	p-val.
Size	5.94	2.12	5.41	2.05	0.54	11.19***	0.00
Log (MV)	6.13	2.04	5.37	1.96	0.77	16.77***	0.00
Log (BV)	5.27	1.99	4.61	1.88	0.66	14.77***	0.00
MB	3.22	3.79	3.04	3.86	0.19	2.1**	0.04
Leverage	0.18	0.18	0.20	0.21	-0.02	-4.66***	0.00
Asset growth ratio	0.19	0.99	0.20	0.69	-0.01	-0.63	0.53
R&D	0.11	0.20	0.10	0.16	0.00	0.78	0.44
Not report R&D dummy	0.17	0.38	0.48	0.50	-0.31	-26.78***	0.00
Capital expenditure	0.06	0.05	0.06	0.06	0.00	-1.48	0.14
Return on asset	0.08	0.20	0.09	0.16	-0.01	-2.74***	0.01
Cash	0.23	0.25	0.21	0.24	0.02	4.28***	0.00
Dividend	0.01	0.02	0.01	0.03	0.00	1.95**	0.05
Tobins'q	2.26	1.78	2.12	1.83	0.14	3.21***	0.00
Sale growth ratio	0.51	22.78	0.23	1.49	0.29	2.07**	0.04
Free cash flow	-0.03	0.16	-0.01	0.14	-0.02	-4.46***	0.00
PPE	0.24	0.18	0.25	0.24	-0.01	-2.44***	0.01
Annual return	0.22	0.92	0.21	0.93	0.00	0.09	0.93
HHI	0.52	0.32	0.51	0.35	0.01	0.85	0.39
%Foreign sales	22.68	25.54	11.83	22.09	10.85	20.92***	0.00
Observations	31,117		1,967				

Table 3
Compositions of Patent Portfolios

The table focuses on the sample that is corresponding to our CCM sample. In this table, US, JP, DE, CA, CN, KR and EP patents represent patents from US, Japanese, German, Canadian, Chinese, Korean and European patent offices, respectively. EE patents represent patents from European patent offices and national patent offices except UK patent office in European Union countries. Panel A presents the composition of firms' patents portfolio. Panel B shows the average and total Hall, Jaffe&Trajtenberg (2001)'s adjusted backward citations at the firm level. Panel C describe the self-citations at the firms level. Panel D represents the popularity of cited authority for the backward citations made by US firms. Panel E describes the popularity of cited authority for the backward citations made by US firms' USPTO patents. For example, the citation maker in panel D is US firms, but the citation maker in panel E is USPTO patents of US firms. Panel F describes generality and originality (Hall, Jaffe & Trajtenberg 2001) for all patents of listed US firms.*Mean* is the average, *St. dev.* is the standard deviation, *Min.* is the minimum, *1%* is 1th percentiles, *25%* is 25th percentiles, *Median* is 50th percentiles, *75%* is 75th percentiles, *99%* is 99th percentiles and *Max.* is maximum.

	Mean	St. dev.	Min.	1%	25%	Median	75%	99%	Max.	Count
Panel A: Patent potfolios of US listed firms from 1976 to 2012										
% US patents	60.87	26.58	0.00	0.00	40.79	60.08	83.13	100.00	100.00	3,889
% JP patents	0.09	1.88	0.00	0.00	0.00	0.00	0.00	1.23	100.00	3,889
% EP patents	10.7	12.86	0.00	0.00	0.00	6.69	17.04	50.00	100.00	3,889
% CN patents	1.44	4.82	0.00	0.00	0.00	0.00	0.79	16.67	100.00	3,889
% DE patents	4.68	8.11	0.00	0.00	0.00	0.00	6.90	33.33	100.00	3,889
% CA patents	3.35	7.13	0.00	0.00	0.00	0.00	4.17	29.12	100.00	3,889
% KR patents	0.64	2.48	0.00	0.00	0.00	0.00	0.00	10.98	61.11	3,889
% Non-US patents	39.13	26.58	0.00	0.00	16.87	39.92	59.21	100.00	100.00	3,889
Panel B: Backward adjusted citations at firm level										
Backward adjusted citations per patents	1.97	1.30	0.10	0.26	1.17	1.69	2.42	6.33	22.75	3,869
Total adjusted backward citations	887.61	6,151.41	0.10	0.36	11.61	56.42	282.68	13,222.69	254,217.69	3,869

	Mean	St. dev.	Min.	1%	25%	Median	75%	99%	Max.	Count
Panel C: Self-citations at firm level										
Total self citations per firm	1,015.64	10,920.11	0.00	0.00	0.00	10.00	109.00	16,311.60	497,279.00	3,869
Percentage of self citations per firm	4.11	5.60	0.00	0.00	0.00	2.27	5.85	26.55	54.52	3,869
Panel D: Popularity of cited authority for the backward citations made by US-firms										
Total number of US patents received	7,120.68	55,688.62	1.00	4.00	80.00	396.00	2,127.00	90,774.05	2,332,830.00	3,869
% US patents	92.70	8.70	33.33	58.36	90.56	95.43	98.32	100.00	100.00	3,869
Total number of EP patents received	100.76	567.82	0.00	0.00	0.00	3.00	27.00	1,936.90	14,019.00	3,869
% EP patents	1.36	2.39	0.00	0.00	0.00	0.53	1.64	12.02	28.57	3,869
Total number of JP patents received	98.50	933.79	0.00	0.00	0.00	2.00	18.00	1,341.40	41,039.00	3,869
% JP patents	1.17	2.48	0.00	0.00	0.00	0.35	1.35	11.48	40.43	3,869
Total number of DE patents received	26.86	156.01	0.00	0.00	0.00	1.00	7.00	575.05	4,599.00	3,869
% DE patents	0.55	1.29	0.00	0.00	0.00	0.05	0.62	5.36	22.22	3,869
Total number of CN patents received	7.84	125.23	0.00	0.00	0.00	0.00	0.00	78.00	5,455.00	3,869
% CN patents	0.05	0.38	0.00	0.00	0.00	0.00	0.00	0.76	10.71	3,869
Total number of EE patents received	139.18	733.22	0.00	0.00	0.00	6.00	42.00	2,889.30	19,288.00	3,869
% EE patents	2.24	3.21	0.00	0.00	0.00	1.27	2.99	15.12	57.14	3,869
Panel E: Popularity of cited authority for the backward citations made by US patents of US-listed firms										
Total number of US patents received	7,009.61	61,478.91	1.00	3.00	54.00	298.00	1,827.00	99,007.82	2,979,119.00	3,786
% US patents	92.36	9.83	29.09	52.05	90.15	95.52	98.81	100.00	100.00	3,786
Total number of EP patents received	97.81	639.76	0.00	0.00	0.00	2.00	22.00	1,973.76	18,152.00	3,786
% EP patents	1.27	2.46	0.00	0.00	0.00	0.41	1.52	11.54	38.46	3,786
Total number of JP patents received	102.33	1,066.20	0.00	0.00	0.00	1.00	16.00	1,451.90	51,033.00	3,786
% JP patents	1.16	2.82	0.00	0.00	0.00	0.23	1.28	11.72	68.18	3,786
Total number of DE patents received	25.47	165.73	0.00	0.00	0.00	0.00	6.00	543.92	5,356.00	3,786
% DE patents	0.50	1.28	0.00	0.00	0.00	0.00	0.52	5.61	22.22	3,786
Total number of CN patents received	15.78	241.99	0.00	0.00	0.00	0.00	0.00	203.24	9,421.00	3,786
% CN patents	0.11	0.59	0.00	0.00	0.00	0.00	0.00	1.99	14.29	3,786
Total number of EE patents received	134.06	814.79	0.00	0.00	0.00	4.00	34.00	2,735.62	24,414.00	3,786
% EE patents	2.10	3.36	0.00	0.00	0.00	1.03	2.79	15.38	57.14	3,786
Table F: Generality and originality at firm level										
Generality	0.34	0.14	0.00	0.00	0.25	0.34	0.43	0.71	0.84	3,869
Originality	0.35	0.15	0.00	0.00	0.26	0.35	0.44	0.69	0.86	3,869

Table 4
Firms with and without Foreign Segments

The table presents sample characteristics between firms with and without foreign segments. The sample consist of 10,780 US firms in the Compustat and CRSP merged dataset from 1976 to 2012. The segment information comes from Compustat segments dataset. Foreign segments are defined as foreign segments with non-zero sales. Continuous variables, except state-level variables, are winsorized at their 1st and 99th percentiles. *Mean* is the average, *St. dev.* is the standard deviation, *Diff.* is the mean difference between firms with and without patent applications (A-B), *t-stat.* is the t-statistic for the difference in means, and *p-val.* is the p-value associated with the t-statistics on the difference in means. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively. Variables definitions are provided in table A 1 in Appendix.

	With foreign segments (A)		No foreign segments (B)		t-test (A-B)		
	Mean	St. dev.	Mean	St. dev.	Diff.	t-stat.	p-val.
Size	5.77	2.09	5.59	2.11	0.19	15.6***	0.00
Log (MV)	5.69	2.10	4.85	1.89	0.83	73.68***	0.00
Log (BV)	4.99	1.97	4.38	1.80	0.61	56.05***	0.00
MB	2.77	3.39	2.24	3.08	0.52	28.42***	0.00
Leverage	0.21	0.19	0.24	0.21	-0.03	-22.27***	0.00
Asset growth ratio	0.16	0.36	0.15	0.35	0.00	0.45	0.65
R&D	0.05	0.08	0.02	0.09	0.02	47.96***	0.00
Not report R&D dummy	0.35	0.48	0.66	0.47	-0.31	-115.92***	0.00
Capital expenditure	0.06	0.06	0.05	0.07	0.01	24.81***	0.00
Return on asset	0.11	0.14	0.07	0.15	0.04	53.14***	0.00
Cash	0.17	0.19	0.14	0.20	0.03	24.84***	0.00
Dividend	0.01	0.02	0.01	0.03	0.00	-3.71***	0.00
Tobins'q	1.95	1.53	1.62	1.39	0.32	39.07***	0.00
Sale growth ratio	0.16	0.38	0.18	0.42	-0.01	-5.64***	0.00
Free cash flow	-0.01	0.13	-0.03	0.13	0.02	22.0***	0.00
PPE	0.26	0.21	0.25	0.28	0.01	6.42***	0.00
Annual return	0.19	0.61	0.18	0.56	0.01	4.0***	0.00
HHI	0.55	0.33	0.40	0.35	0.14	75.24***	0.00
%Foreign patents applications	16.34	29.61	3.64	16.28	12.70	93.57***	0.00
Observations	61,337		64,266				

Table 5
Firms with and without Foreign Subsidiaries

The table presents sample characteristics between firms with and without non-US subsidiaries. The sample consist of 8,441 US firms in the Compustat and CRSP merged dataset from 1994 to 2012. The subsidiaries information comes from Exhibit 21 dataset. Continuous variables, except state-level variables, are winsorized at their 1st and 99th percentiles. *Mean* is the average, *St. dev.* is the standard deviation, *Diff.* is the mean difference between firms with and without patent applications (A-B), *t-stat.* is the t-statistic for the difference in means, and *p-val.* is the p-value associated with the t-statistics on the difference in means. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively. Variables definitions are provided in table A 1 in Appendix.

	With foreign subsidiaries (A)		No foreign subsidiaries(B)		t-test (A-B)		
	Mean	St. dev.	Mean	St. dev.	Diff.	t-stat.	p-val.
Size	6.46	2.02	5.64	1.93	0.82	56.45***	0.00
Log (MV)	6.44	1.92	5.04	1.72	1.39	104.0***	0.00
Log (BV)	5.61	1.82	4.45	1.65	1.16	89.65***	0.00
MB	3.06	3.64	2.52	3.44	0.54	20.56***	0.00
Leverage	0.21	0.20	0.21	0.22	0.00	-2.0**	0.05
Asset growth ratio	0.16	0.39	0.15	0.38	0.00	1.19	0.23
R&D	0.05	0.09	0.04	0.10	0.01	15.8***	0.00
Not report R&D dummy	0.40	0.49	0.61	0.49	-0.21	-57.59***	0.00
Capital expenditure	0.05	0.05	0.04	0.07	0.01	12.78***	0.00
Return on asset	0.10	0.15	0.04	0.17	0.05	42.38***	0.00
Cash	0.18	0.21	0.16	0.22	0.03	15.79***	0.00
Dividend	0.01	0.02	0.01	0.03	0.00	-9.89***	0.00
Tobins'q	2.06	1.58	1.78	1.59	0.28	24.14***	0.00
Sale growth ratio	0.17	0.40	0.18	0.44	-0.01	-3.99***	0.00
Free cash flow	0.01	0.13	-0.02	0.15	0.03	31.54***	0.00
PPE	0.23	0.21	0.21	0.27	0.02	11.2***	0.00
Annual return	0.18	0.63	0.15	0.59	0.02	5.21***	0.00
HHI	0.48	0.33	0.35	0.33	0.13	51.8***	0.00
%Foreign sales	21.62	26.59	3.47	13.06	18.15	119.65***	0.00
%Foreign patents applications	17.28	30.18	5.60	19.78	11.69	62.86***	0.00
Observations	39,041		34,804				

Table 6
OLS Regressions of the Propensity to Foreign Patents on Foreign Market Activities

Column 1 and 2 of this table reports results of regressing %foreign patents on lagged %foreign sales. Column 1 and 2 of this table reports results of regressing %matched foreign patents on lagged %matched foreign sales. Regressions on column 1 and 3 include year and industry fixed effects; standard errors are clustered at the industry level. Regressions on column 2 and 4 include year and firm fixed effects; standard errors are clustered at the firm level. Variables definitions are provided in table A 1 in Appendix.

	(1)	(2)	(3)	(4)
	%Foreign patents	%Foreign patents	%Matched foreign patents	%Matched foreign patents
%Foreign sales at t-1	0.115***	0.026**		
	(7.025)	(2.418)		
%Matched foreign sales at t-1			0.054***	0.031***
			(4.489)	(7.018)
Control variables				
$Size_{t-1}$	0.015***	0.009***	0.005	-0.002
	(3.953)	(3.538)	(1.401)	(-0.554)
$Leverage_{t-1}$	-0.011	0.010	0.015	0.010
	(-1.165)	(1.182)	(1.353)	(1.071)
ROA_{t-1}	-0.016	-0.006	-0.005	-0.004
	(-0.868)	(-0.516)	(-0.343)	(-0.355)
AGR_{t-1}	-0.002	0.001	-0.009***	-0.003*
	(-0.639)	(0.380)	(-2.930)	(-1.655)
FCF_{t-1}	-0.009	0.031***	0.019	0.035**
	(-0.567)	(2.606)	(1.126)	(2.359)
$Cash_{t-1}$	0.058***	0.025***	0.004	-0.006
	(3.402)	(2.583)	(0.390)	(-0.695)
$R\&D_{t-1}$	0.276***	0.051	-0.010	-0.018
	(4.669)	(1.570)	(-0.678)	(-0.826)
$R\&D\ dummy_{t-1}$	-0.062***	-0.012**	-0.015***	-0.000
	(-9.699)	(-2.566)	(-4.169)	(-0.010)
$Capex_{t-1}$	0.039	0.047**	0.043	-0.001
	(1.147)	(2.174)	(1.124)	(-0.023)
PPE_{t-1}	0.036**	0.015	0.003	0.003
	(2.536)	(1.404)	(0.238)	(0.270)
$\Delta\ Sales_{t-1}$	0.001	-0.002	0.002	-0.001
	(0.427)	(-1.062)	(0.787)	(-0.466)
$Return_{t-1}$	-0.003*	0.000	-0.003	-0.003**
	(-1.892)	(0.008)	(-1.599)	(-2.068)
Tobins' q_{t-1}	0.003	0.002	0.002	0.001
	(1.592)	(1.390)	(1.259)	(0.553)
$ln(MktVal)_{t-1}$	0.014***	0.004**	0.002	0.001
	(1.774)	(0.088)	(1.768)	(0.177)
HHI_{t-1}	0.004	0.006	-0.015**	0.007
	(0.475)	(0.836)	(-2.381)	(0.956)
Constant	-0.074***	0.012	-0.008	0.043
	(-3.510)	(0.407)	(-0.772)	(1.315)
Observations	102,130	101,374	365,772	365,146
Adj. R-squared	0.280	0.488	0.099	0.45
Cluster	Industry	Firm	Industry	Firm
Industry fixed effect	Yes	No	Yes	No
Firm fixed effect	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 7
2SLS Regressions of %Foreign Patents on IVs (FTA dummy or FTA cum dummy)

The table reports results of regressing %foreign patents on lagged $\widehat{\%\text{foreign sales}}_{t-1}$ that is estimated by lagged FTA dummy and FTA cum dummy. Column 1 and 3 are first-stage regressions. Column 2 and 4 are second-stage regressions. All regressions include year and industry fixed effects. Robust t-statistics (clustered by industry) are in parentheses. Variables definitions are provided in table A 1 in Appendix.

	(1)	(2)	(3)	(4)
	%Foreign sales_{t-1}	%Foreign patents	%Foreign sales_{t-1}	%Foreign patents
Instruments				
FTA dummy_{t-1}	0.269***			
	(22.343)			
FTA cum dummy_{t-1}			0.014***	
			(15.718)	
Instrumented variable				
%Foreign sales_{t-1}		0.117***		0.064*
		(3.645)		(1.781)
Control variables				
Size_{t-1}	0.026***	0.015***	0.030***	0.016***
	(7.613)	(3.653)	(8.567)	(3.903)
Leverage_{t-1}	-0.009	-0.012	-0.012	-0.012
	(-0.913)	(-1.180)	(-0.960)	(-1.221)
ROA_{t-1}	0.045***	-0.016	0.041**	-0.014
	(2.856)	(-0.893)	(2.414)	(-0.768)
AGR_{t-1}	-0.013***	-0.002	-0.014***	-0.003
	(-5.272)	(-0.635)	(-5.311)	(-0.909)
FCF_{t-1}	-0.003	-0.008	0.002	-0.008
	(-0.233)	(-0.537)	(0.139)	(-0.492)
Cash_{t-1}	-0.009	0.058***	-0.000	0.058***
	(-0.417)	(3.431)	(-0.019)	(3.623)
$\text{R\&D}_{t-1}$	0.039	0.277***	0.037	0.279***
	(0.632)	(4.657)	(0.571)	(4.918)
R&D dummy_{t-1}	-0.035***	-0.062***	-0.036***	-0.064***
	(-6.226)	(-9.586)	(-5.831)	(-9.711)
Capex_{t-1}	-0.019	0.039	-0.030	0.036
	(-0.776)	(1.158)	(-1.126)	(1.079)
PPE_{t-1}	-0.046***	0.036**	-0.046**	0.033**
	(-3.125)	(2.562)	(-2.568)	(2.307)
Δ Sales_{t-1}	-0.009***	0.001	-0.011***	0.001
	(-3.705)	(0.408)	(-3.606)	(0.212)
Return_{t-1}	0.001	-0.003*	0.000	-0.003*
	(0.452)	(-1.908)	(0.207)	(-1.852)
Tobins' q_{t-1}	-0.000	0.003	0.001	0.003
	(-0.002)	(1.583)	(0.489)	(1.575)
$\ln(\text{MktVal})_{t-1}$	-0.001	0.014***	-0.002	0.014***
	(-0.239)	(3.581)	(-0.564)	(3.458)
HHI_{t-1}	0.006	0.005	0.007	0.005
	(0.845)	(0.559)	(0.830)	(0.603)
Constant	-0.038*	-0.103***	-0.044**	-0.099***
	(-1.940)	(-3.350)	(-2.311)	(-3.156)
Observations	102,132	102,132	102,132	102,132
F-statistic	57.84***	N/A	32.76***	N/A
Adj. R-squared	0.484	0.283	0.434	0.282
Cluster	Industry	Industry	Industry	Industry
Industry fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 8
2SLS Regressions of %Foreign Patents on IVs (BIT dummy or BIT cum dummy)

The table reports results of regressing %foreign patents on lagged %foreign$\widehat{\text{sales}}_{t-1}$ that is estimated by lagged BIT dummy and BIT cum dummy. Column 1 and 3 are first-stage regressions. Column 2 and 4 are second-stage regressions. All regressions include year and industry fixed effects. Robust t-statistics (clustered by industry) are in parentheses. Variables definitions are provided in table A 1 in Appendix.

	(1)	(2)	(3)	(4)
	%Foreign sales_{t-1}	%Foreign patents	%Foreign sales_{t-1}	%Foreign patents
Instruments				
BIT dummy_{t-1}	0.274***			
	(27.588)			
BIT cum dummy_{t-1}			0.006***	
			(20.433)	
Instrumented variable				
%Foreign sales_{t-1}		0.118***		0.128***
		(4.429)		(4.115)
Control variables				
Size_{t-1}	0.023***	0.014***	0.026***	0.014***
	(6.103)	(3.715)	(7.937)	(3.669)
Leverage_{t-1}	-0.005	-0.012	-0.008	-0.011
	(-0.589)	(-1.182)	(-0.850)	(-1.174)
ROA_{t-1}	0.042***	-0.016	0.038**	-0.017
	(2.655)	(-0.893)	(2.396)	(-0.914)
AGR_{t-1}	-0.012***	-0.002	-0.013***	-0.002
	(-5.173)	(-0.643)	(-4.894)	(-0.582)
FCF_{t-1}	-0.010	-0.008	-0.002	-0.008
	(-0.769)	(-0.538)	(-0.183)	(-0.547)
Cash_{t-1}	-0.001	0.058***	0.002	0.058***
	(-0.033)	(3.426)	(0.091)	(3.397)
$\text{R\&D}_{t-1}$	0.052	0.276***	0.045	0.276***
	(0.885)	(4.656)	(0.776)	(4.623)
R&D dummy_{t-1}	-0.034***	-0.062***	-0.032***	-0.061***
	(-6.308)	(-9.686)	(-5.546)	(-9.598)
Capex_{t-1}	-0.018	0.039	-0.022	0.039
	(-0.795)	(1.156)	(-0.929)	(1.172)
PPE_{t-1}	-0.028**	0.036**	-0.034**	0.036***
	(-2.100)	(2.571)	(-2.178)	(2.621)
Δ Sales_{t-1}	-0.008***	0.001	-0.009***	0.001
	(-3.112)	(0.406)	(-3.578)	(0.439)
Return_{t-1}	0.001	-0.003*	0.000	-0.003*
	(0.401)	(-1.909)	(0.342)	(-1.920)
Tobins' q_{t-1}	-0.001	0.003	-0.000	0.003
	(-0.621)	(1.583)	(-0.102)	(1.585)
$\ln(\text{MktVal})_{t-1}$	0.001	0.014***	-0.001	0.014***
	(0.226)	(3.583)	(-0.269)	(3.602)
HHI_{t-1}	0.008	0.005	0.008	0.005
	(1.147)	(0.558)	(1.083)	(0.548)
Constant	-0.044**	-0.103***	-0.043**	-0.104***
	(-2.153)	(-3.349)	(-2.258)	(-3.359)
Observations	102,132	102,132	102,132	102,132
F-statistic	85.51***	N/A	46.89***	N/A
Adj. R-squared	0.516	0.283	0.500	0.283
Cluster	Industry	Industry	Industry	Industry
Industry fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 9
2SLS Regressions of %Matched Foreign Patents on IVs (FTA, FTA cum and BIT cum dummy)

The table reports results of regressing %matched foreign patents on lagged %matched foreign sales$_{t-1}$ that is estimated by lagged FTA, FTA cum and BIT cum dummy. Column 1, 3 and 5 are first-stage regressions. Column 2, 4 and 6 are second-stage regressions. All regressions include year and industry fixed effects. Robust t-statistics (clustered by industry) are in parentheses. Variables definitions are provided in table A 1 in Appendix.

	(1)	(2)	(3)	(4)	(5)	(6)
	%Matched foreign sales$_{t-1}$	%Matched foreign patents	% Matched foreign sales$_{t-1}$	%Matched foreign patents	%Matched foreign sales$_{t-1}$	%Matched foreign patents
Instrument						
FTA dummy$_{t-1}$	0.016***					
	(3.159)					
FTA cum dummy$_{t-1}$			0.002***			
			(3.475)			
BIT cum dummy$_{t-1}$					0.009***	
					(25.335)	
Instrumented variable						
%Matched foreign sales$_{t-1}$		-0.093		0.002		0.196***
		(-0.771)		(0.013)		(6.533)
Control variables						
Size$_{t-1}$	-0.001	0.005	-0.000	0.006	-0.001	0.006
	(-0.211)	(1.347)	(-0.155)	(1.328)	(-0.205)	(1.280)
Leverage$_{t-1}$	0.013**	0.018	0.013**	0.017	0.013**	0.015
	(2.237)	(1.329)	(2.213)	(1.267)	(2.047)	(1.076)
ROA$_{t-1}$	0.008	-0.003	0.009	-0.004	-0.005	-0.006
	(0.828)	(-0.186)	(0.916)	(-0.240)	(-0.409)	(-0.341)
AGR$_{t-1}$	0.001	-0.011***	0.001	-0.011***	0.001	-0.011***
	(0.337)	(-2.918)	(0.334)	(-2.921)	(0.852)	(-2.920)
FCF$_{t-1}$	0.003	0.015	0.002	0.015	0.003	0.015
	(0.360)	(0.773)	(0.304)	(0.758)	(0.332)	(0.730)
Cash$_{t-1}$	0.038***	0.008	0.039***	0.004	0.046***	-0.003
	(4.832)	(0.813)	(4.820)	(0.438)	(5.564)	(-0.277)
R&D$_{t-1}$	0.014	-0.000	0.015	-0.002	0.018	-0.005
	(0.666)	(-0.005)	(0.719)	(-0.097)	(0.770)	(-0.308)
R&D dummy$_{t-1}$	0.005	-0.019***	0.005	-0.019***	0.008***	-0.020***
	(1.557)	(-3.939)	(1.531)	(-4.062)	(2.641)	(-4.410)
Capex$_{t-1}$	-0.012	0.051	-0.013	0.052	-0.003	0.055
	(-0.362)	(0.991)	(-0.391)	(1.013)	(-0.090)	(1.048)
PPE$_{t-1}$	0.000	0.007	0.001	0.007	0.005	0.006
	(0.020)	(0.346)	(0.066)	(0.335)	(0.612)	(0.311)
Δ Sales$_{t-1}$	0.001	0.002	0.001	0.002	0.002	0.002
	(0.478)	(0.603)	(0.459)	(0.586)	(0.880)	(0.549)
Return$_{t-1}$	0.001	-0.003	0.001	-0.003	0.000	-0.003
	(0.547)	(-1.267)	(0.597)	(-1.286)	(0.201)	(-1.333)
Tobins' q$_{t-1}$	-0.002***	0.001	-0.002***	0.001	-0.002**	0.002
	(-2.748)	(0.563)	(-2.713)	(0.650)	(-2.211)	(0.822)
ln(MktVal)$_{t-1}$	0.001	0.004	0.001	0.004	0.001	0.004
	(0.313)	(1.079)	(0.263)	(1.049)	(0.428)	(0.979)
HHI$_{t-1}$	0.006	-0.018**	0.006	-0.019**	0.005	-0.020***
	(1.474)	(-2.362)	(1.456)	(-2.458)	(1.281)	(-2.722)
Constant	0.038***	-0.041**	0.040***	-0.046**	-0.019*	-0.056***
	(4.323)	(-2.043)	(4.685)	(-2.310)	(-1.963)	(-3.010)
Observations	307,866	307,866	307,866	307,866	307,866	307,866
F-statistic	4.89***	N/A	5.05***	N/A	64.92***	N/A
Adj. R-squared	0.166	0.133	0.163	0.138	0.333	0.130
Cluster	Industry	Industry	Industry	Industry	Industry	Industry
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 10
2SLS Regressions of %Foreign Patents on IVs (FTA dummy or BIT cum dummy)

The table reports results of regressing %foreign patents on lagged %foreign$\widehat{\text{sales}}_{t-1}$ that is estimated by lagged FTA dummy and BIT cum dummy. Column 1 and 3 are first-stage regressions. Column 2 and 4 are second-stage regressions.Regressions on column 1 and 2 include year and firm fixed effects; standard errors are clustered at the firm level. Regressions on column 3 and 4 include year and industry fixed effects; standard errors are clustered at the industry level. Robust t-statistics (clustered by industry) are in parentheses. Variables definitions are provided in table A 1 in Appendix.

	(1)	(2)	(3)	(4)
	%Foreign sales_{t-1}	%Foreign patents	%Foreign sales_{t-1}	%Foreign patents
Instruments				
FTA dummy_{t-1}	0.089***		0.145***	
	(11.265)		(13.053)	
BIT cum dummy_{t-1}	0.004***		0.004***	
	(14.167)		(14.992)	
Instrumented variable				
%Foreign sales_{t-1}		0.040***		0.124*
		(1.654)		(4.046)
Control variables				
Size at t-1	0.020***	0.009***	0.025***	0.015***
	(8.430)	(3.329)	(7.147)	(3.875)
Leverage at t-1	0.001	0.010	-0.007	-0.012
	(0.231)	(1.183)	(-0.775)	(-1.277)
ROA at t-1	-0.034***	-0.005	0.041***	-0.016
	(-3.865)	(-0.452)	(2.669)	(-0.882)
AGR at t-1	-0.009***	0.001	-0.012***	-0.003
	(-6.280)	(0.440)	(-4.511)	(-0.855)
FCF at t-1	0.025***	0.030**	-0.005	-0.007
	(3.347)	(2.572)	(-0.446)	(-0.449)
Cash at t-1	0.005	0.025**	-0.005	0.056***
	(0.672)	(2.575)	(-0.228)	(3.353)
R&D at t-1	0.001	0.051	0.042	0.274***
	(0.050)	(1.580)	(0.753)	(4.608)
R&D dummy at t-1	-0.005	-0.012**	-0.033***	-0.061***
	(-1.230)	(-2.546)	(-5.895)	(-9.593)
Capex at t-1	0.009	0.047**	-0.015	0.038
	(0.623)	(2.189)	(-0.669)	(1.113)
PPE at t-1	-0.006	0.016	-0.038***	0.036**
	(-0.601)	(1.435)	(-2.631)	(2.577)
Δ Sales at t-1	-0.002*	-0.002	-0.009***	0.000
	(-1.720)	(-1.054)	(-3.830)	(0.153)
Return at t-1	0.004***	-0.000	0.000	-0.003*
	(5.324)	(-0.044)	(0.196)	(-1.743)
Tobins' q at t-1	-0.003***	0.002	-0.000	0.003
	(-2.867)	(1.414)	(-0.038)	(1.571)
ln(MktVal)at t-1	-0.003**	0.004**	-0.001	0.014***
	(-2.114)	(2.129)	(-0.213)	(3.685)
HHI at t-1	0.001	0.006	0.006	0.007
	(0.177)	(0.832)	(0.963)	(0.779)
Observations	101,374	101,374	101,374	101,374
F-statistic	72.23***	N/A	40.11***	N/A
Adj. R-squared	0.484	0.283	0.434	0.282
Cluster	Firm	Firm	Industry	Industry
Hansen J statistic	N/A	0.707	N/A	0.392
Firm fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	No	No
Year fixed effect	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 11
OLS Regressions of the Propensity to Foreign Patents on the Strength of Patent Rights

Column 1 of the table shows the regressions of %foreign patents corresponding to patent offices on lagged IP protection in a given country. Column 2 shows the regressions of %foreign patents on lagged average IP protection, foreign market activities (measured by %foreign sales) and foreign production (%foreign capex). All regressions include year and industry fixed effects. Robust t-statistics (clustered by industry) are in parentheses. Variables definitions are provided in table A 1 in Appendix.

	(1)	(3)
	%Foreign patents	%Foreign patents
Strength of Patent Right$_{t-1}$	0.015***	
	(10.180)	
Average Strength of Patent Right$_{t-1}$		0.053***
		(5.346)
%Foreign sales$_{t-1}$		0.073***
		(29.248)
%Foreign capex$_{t-1}$		-0.009
		(-0.423)
Control Variables		
Size$_{t-1}$	-0.009***	0.006**
	(-3.131)	(2.309)
Leverage$_{t-1}$	0.002	-0.010
	(0.270)	(-1.518)
ROA$_{t-1}$	0.063***	-0.002
	(5.043)	(-0.151)
AGR$_{t-1}$	0.002	-0.001
	(1.360)	(-0.628)
FCF$_{t-1}$	-0.024	-0.021
	(-1.425)	(-1.622)
Cash$_{t-1}$	-0.011	0.025***
	(-1.582)	(2.816)
R&D$_{t-1}$	-0.033***	0.118***
	(-3.404)	(3.436)
R&D dummy$_{t-1}$	0.013	-0.036***
	(1.496)	(-8.977)
Capex$_{t-1}$	0.008	0.011
	(0.260)	(0.450)
PPE$_{t-1}$	0.002	0.024***
	(0.146)	(2.736)
Δ Sales$_{t-1}$	-0.003	0.000
	(-1.478)	(0.174)
Return$_{t-1}$	0.004***	-0.001
	(3.844)	(-0.566)
Tobins' q$_{t-1}$	-0.002***	0.001
	(-3.272)	(1.293)
ln(MktVal)$_{t-1}$	-0.010***	0.008***
	(-2.832)	(3.099)
HHI$_{t-1}$	0.005	-0.001
	(0.826)	(-0.114)
Constant	0.154***	-0.026*
	(9.647)	(-1.911)
Observations	7,674,102	102,009
Cluster	Industry	Industry
Firm fixed effect	No	NO
Industry	Yes	Yes
Time fixed effect	Yes	Yes
Adj. R-squared	0.209	0.496

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

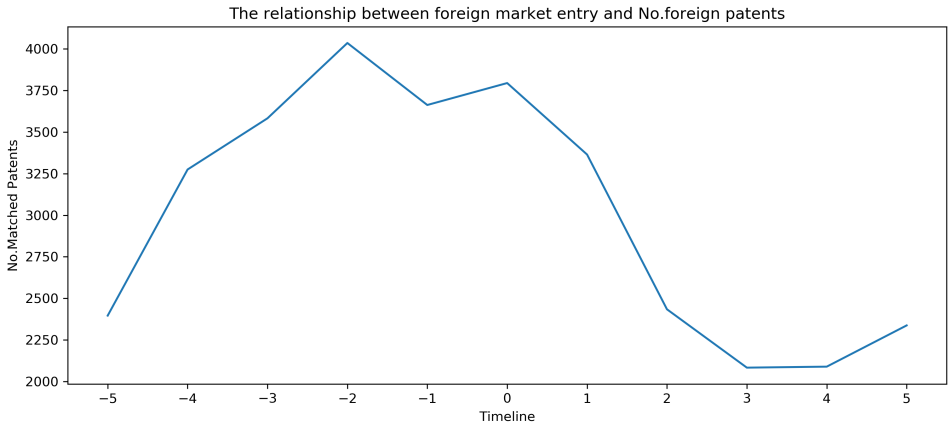

Figure 1
This graph shows the change in number of patents before and after foreign market entry

Appendix

Table A1
Variable Definitions

Variable Names	Variable Definitions	Code
Size	Log of total assets	Log(AT)
Log(MV)	Log of market value	Log(PRCC_F*CSHO)
MB	Market to book value ratio	(PRCC_F*CSHO)/CEQ
Leverage	Total liabilities divided by total assets	(DLTT+DLC)/AT
Asset growth ratio	Annual assets growth	(AT_t/AT_{t-1})-1
R&D	R&D expenditure divided by total assets	XRD/AT
Not report R&D dummy	Indicator variable: 1 if a firm do not reported zero or positive R&D expenditure; 0 otherwise.	
Capital expenditure	Capital expenditure divided by total assets	CAPX/AT
Return on asset	Income before depreciation and amortization divided by total assets	OIBDP/AT
Cash	Cash and short-term investment divided by total assets	CHE/AT
Tobins'q	Market value of equity divided by total assets	(AT+CSHO*PRCC_F-CEQ)/AT
Sale growth ratio	Annual sales growth	$(SALE_t/SALE_{t-1})$-1
Free cash flow	Free cash flow divided by total assets	(OANCF-CAPX)/AT
PPE	Net property, plant, and equipment divided by total assets	PPENT/AT
Annual return	Annual stock return	$(((PRCC\_F_t+DVPSX\_F_t)/AJEX_t)/(PRCC\_F_{t-1}/AJEX_{t-1}))$-1
%Foreign sales	Total foreign sales divided by total sales at year t	
%Foreign patents	Total foreign patent applications divided by total patent applications at year t	
HHI	Herfindal industry concentration index	

Table A2
Descriptive Statistics

The table reports descriptive statistics for 10,780 firms and 125,603 observations from 1976 to 2012. Continuous variables, except state-level variables, are winsorized at their 1st and 99th percentiles. *Mean* is the average, *St. dev.* is the standard deviation, *Min.* is the minimum, *1%* is 1th percentiles, *25%* is 25th percentiles, *Median* is 50th percentiles, *75%* is 75th percentiles, *99%* is 99th percentiles and *Max.* is maximum. Variables definitions are provided in table A 1 in Appendix.

	Mean	St. dev.	Min.	1%	25%	Median	75%	99%	Max.	Count
Size	5.68	2.10	1.19	1.19	4.13	5.59	7.13	10.87	10.87	125,603
Log(MV)	5.26	2.04	1.02	1.02	3.80	5.17	6.66	10.34	10.34	125,603
MB	2.49	3.24	-5.29	-5.29	1.02	1.65	2.83	21.63	21.63	125,603
Leverage	0.22	0.20	0.00	0.00	0.05	0.18	0.35	0.89	0.89	125,603
Asset growth ratio	0.15	0.36	-0.45	-0.45	-0.01	0.08	0.20	2.14	2.14	114,546
R&D	0.07	0.11	0.00	0.00	0.00	0.03	0.09	0.65	0.65	61,190
Not report R&D dummy	0.51	0.50	0.00	0.00	0.00	1.00	1.00	1.00	1.00	125,603
Capital expenditure	0.06	0.06	0.00	0.00	0.01	0.04	0.08	0.34	0.34	125,603
Return on asset	0.09	0.15	-0.63	-0.63	0.03	0.11	0.17	0.43	0.43	125,603
Cash	0.15	0.20	0.00	0.00	0.02	0.07	0.20	0.89	0.89	125,603
Tobins'q	1.77	1.47	0.63	0.63	1.02	1.25	1.89	10.01	10.01	125,603
Sale growth ratio	0.17	0.40	-0.60	-0.60	0.00	0.10	0.23	2.55	2.55	113,403
Free cash flow	-0.02	0.13	-0.63	-0.63	-0.06	0.00	0.05	0.26	0.26	125,603
PPE	0.26	0.25	0.00	0.00	0.05	0.19	0.40	0.90	0.90	125,603
Annual return	0.18	0.59	-0.79	-0.79	-0.15	0.10	0.38	2.97	2.97	113,906
HHI	0.47	0.35	0.02	0.02	0.16	0.38	0.82	1.00	1.00	125,603
%Foreign sales	10.50	20.36	0.00	0.00	0.00	0.00	12.19	89.83	89.83	125,603