Does Licensing Induce Technological Spillovers to Domestic Firms?

Luis Castro*

Current Draft: February 29, 2012

Abstract

Productivity differences can explain differences in economic growth across countries, it has been demonstrated that foreign presence of a Multinational Enterprise (MNE) in a developing country is one of the most important methods through which technology transfer occurs. This presence could be in the form of Foreign Direct Investment (FDI), licensing, and imports from the developing country. However, the way and the effectiveness in which each type of foreign presence affects domestic productivity is still unclear.

In this paper, I study licensing as one of the channels through which foreign technology is transferred to domestic plants. This technology transfer can occur in the same industry and in related industries, which result in technology spillovers that can affect both intra-industry and inter-industry productivity. Moreover, the institutional framework of the country can affect the type of foreign presence adopted by MNE's in the host country. Therefore, it is important to analyze the effect of a change in the institutional framework on technology spillovers. This can be achieved by analyzing a set of new - stronger - Intellectual Property Rights (IPR).

Using Chilean plant level data for the 2001-2007 period I find that there are positive inter-industry spillover effects when licensing is done in downstream sectors which result in higher productivity for domestic plants in upstream sectors (backward linkages).

Moreover, stronger IPR measures increases intra-sector spillover effects while it decreases the productivity of domestic firms in inter-industry sectors. I also find that there are greater spillover effects in plants with higher productivity.

JEL Codes: F14, O54, O3.

Keywords: Spillovers; Technology transfer; Intellectual Property Rights; Chile.

*Department of Economics. University of Colorado at Boulder. Boulder, Colorado 80309-0256.
e-mail address: Luis.Castropenarrieta@colorado.edu

1 Introduction

Many authors have recognized that productivity differences can explain differences in economic growth across countries. Numerous studies have demonstrated the importance of technology transfer in order reduce the productivity gap between developed and developing nations. As Montalvo and Yafeh (1994) note:

> "*Japan's economic growth in the postwar period has been characterized by a very rapid growth in productivity, achieved, to a great extent, through massive borrowing of technology from more advanced countries.*"

However, the best way to attract new technology into a developing country is not entirely clear. There are many channels that this phenomenon can use in order to reach the host country. Among others, Yasar and Morrison Paul (2007) identify Foreign Direct Investment (FDI), exports, licensing and imports as possible channels of technology transfer from a Multinational Enterprise (MNE) to a host country. Moreover, the institutional framework of the host country is also key to attracting MNE's presence. In this sense, Intellectual Property Rights (IPR) also play an important role regarding foreign presence in a country.

Therefore, it is important to analyze the effect of different modes of entry and also IPR on the productivity of firms - between and within industries. More specifically, there could be externalities from foreign presence into the domestic economy. These externalities or *"spillovers"* could happen horizontally (within the same sector) or vertically (across different sectors); thus, foreign presence could affect *upstream* sectors (mainly the providers of inputs for a given industry) or *downstream* sectors (the buyers of production). If there is a large positive effect for either upstream or downstream industries, that can provide the grounds for a more open policy toward foreign presence (either through FDI or through licensing).

However, if the effect to other industries is negative, then that could cause the country to be more restrictive in pursuing foreign presence since that might hurt domestic firms more than helping them.[1] This issue is crucial in order to decide economic policy toward foreign presence in the country.

In order to analyze this, I use Chilean manufacturing data for the period 2001-2007. First I examine the effects of foreign presence in terms of FDI and licensing within and between manufacturing industries.

Then I introduce the IPR measure to see how it affects the relationship and if there is any improvement in some transfer of technology once this change in IPR is implemented.

There are a lot of studies that have dealt with foreign presence and the linkages and spillover effects that could have into domestic firms. Most of these studies focus on Foreign Direct Investment as a form of foreign presence in a host country. Although there are some studies at the industry level that find a positive effect of Foreign Direct Investment (FDI) on productivity within the same sector, most firm-level studies find a negative effect of FDI in the process of technology transfer within the same industry. Among the most important firm level studies are Aitken and Harrison (1999) which uses data from Venezuela, Javorcik (2004) with data from Lithuania, and Javorcik and Spatareanu (2008) which looks at Romania. An important contribution is done by Damijan et al. (2008) since they examine the spillover effect of FDI on productivity for ten different transition economies.

Some people argue that Foreign Direct Investment (FDI) is the most direct way to transfer technology. Others would say that FDI harms domestic firms, if they have strong market power, in the sense that domestic firms may not have access to foreign technology and therefore cannot compete with foreign firms.

A MNE can decide to service a foreign market through either FDI, exports, or licenses in the host country. This decision depends on the institutional context in the host country, complexity of the production process, imitative capacity of the host country, regulation, etc.

Moreover, since the MNE can choose the mode of entry into the host country, it is important to determine which channel best diffuses technology. For instance some countries have

[1] This could be true when the market structure is such that foreign firms have overwhelming market power.

been notorious for having policies directed to attract FDI while others introduce policies to deter or reduce it.

This paper tries to analyze the existence and magnitude of the diffusion of technology in Chile during the period 2001 to 2007 since in this period there has been an important policy change regarding Intellectual Property Rights (IPR), increasing its overall strength.

There are a few studies like this done in the past. The closest one in spirit being Lopez (2008). He analyzes the effects of licensing on productivity in Chile during 1990-1999. Another influential study is the one done by Javorcik (2004) where she analyzes the effect of FDI on productivity through backward linkages.

An important contribution of this study is to validate and complement the previous study done by Lopez (2008). This can be achieved in three ways. First, the time frame of this study is more recent. This is important since Chile has been growing steadily in the last decade; thus, it is quite plausible that the imitative capabilities in the country have changed. Second, Lopez (2008) cannot include the change in IPR that occurred in 2005, which might affect the choice of entry mode of MNE's and thus, affect the level of licensing. Third, it is possible to determine different magnitudes of spillover effects depending on the productivity level of the firm as in Damijan et al. (2008).

Moreover, to the best of my knowledge, aside from Lopez (2008) there has been a lack of studies that pin down licensing as the source of spillovers that affect the productivity of firms. Specially in a case like Chile where it is the case that licensing is replacing FDI after the strengthening of IPR.[2]

Related Literature

There are two strands of literature that are relevant for this study. First are studies that relate IPR reforms to licensing. The second strand is the effect of licensing on firm productivity as a means of technology transfer.

[2] This is noted in Castro 2012.

Regarding the first strand, there are some empirical studies that reveal the importance of IPR strength on licensing.[3] Yang and Maskus (2001) study licensing by U.S. firms in 23 countries. They do not find a significant effect of IPR on licensing for affiliated firms, while they find a U-shaped relation for non-affiliated firms. That means that for low levels of IPR host countries have limited imitative capabilities, thus the *market power* effect would dominate while at higher levels of strength the *market expansion* effect would dominate.[4]

In another study, Smith (2001) examines the effect of foreign patent rights on U.S. exports, affiliate sales in the host country and licenses. The approach used is new since the effect of IPR on the three forms of decisions for the MNE (export, sales by affiliate, and licensing)are examined simultaneously . The data represents 50 countries in 1989.

Smith (2001) tests whether or not stronger IPR increase exports; sales via affiliate; or licenses in order to determine whether the *market expansion* or the *market power* effect is stronger. Other tests examined are whether strong IPR leads to transfer of knowledge to the host country and if the transfer of knowledge occurs within the same firm or not.[5]

The findings show a positive relation between IPR strength and sales of U.S. affiliates in a host country. There is also a positive effect of IPR on the licenses given to foreign firms. However, the level of exports is not significantly affected by IPR. This leads to the conclusion that strong IPR have a *market expansion* effect in the host country instead of a *market power* effect. Moreover, the effect is larger in countries that have strong imitative capacity.

Also, stronger IPR's increase the location advantage for the MNE since there is a larger effect in licenses than in affiliate sales. Thus, this would mean that it is possible that MNE's reduce the level of FDI and use licensing instead.

In a more recent study, Branstetter et al. (2006) analyze the effect of IPR reforms in

[3] Park (2008) reviews issues behind IPR strength and innovation.

[4] The market expansion effect refers to higher production (either through exports, sales, or licenses) in the foreign market since the technology being transferred is better protected. The market power refers to the fact that stronger IPR confers more market power to the MNE in the host country, reducing the level of production in the foreign market.

[5] If sales done by the affiliate are highly affected by the reform, then the knowledge transfer occurs within the same firm while if the reform affects licenses, then the knowledge is given to an external firm.

sixteen countries during the 1982-1999 period. Using U.S. firm-level data, they analyze the effects of stronger IPR measures on international technology transfer.

They conclude that royalty payments for technology transferred increased at the time of the reform. Also, R&D expenditures in the host country increased, especially for firms that use patents extensively. This study represents a breakthrough in the literature since panel data is required to perform a more complete analysis.

Moreover, some studies focus on the effect of IPR on different modes of entry. Nicholson (2002) emphasizes that different IPR regimes affect industries in different ways. He points out that depending on the effect on the industry, MNE's will react by changing the mode of entry to the host country. He concludes that firms with high risk of imitation will tend to enter through FDI; while firms with low risk will tend to license the production.

Saggi et al. (2005) propose a model in which MNE's have the choice to transfer technology through FDI or licensing. Increasing IPR raises the cost of imitation in the host country, thus, it increases both modes of entry. Moreover, they point out that increasing IPR's opens the possibility of higher levels of licensing since it is easier to enforce the contracts in place.

The second strand of literature is related to the effect of licensing on productivity. Kathuria (2000) stress the point that most studies that look at spillover effects might be underestimating the effect of foreign presence if they only take FDI as a channel of spillovers. They find positive spillover effects depending on the nature of the industry of the firm.

Alvarez et al. (2002) find that local spending on licensing has a high level of return. Thus, the "investment" done in licensing improved the performance and productivity of Chilean firms during the 1990's.

Moreover, as noted by Lopez (2008) the effects of licensing transcends to not only the same industry but also there are some inter-industry effects. Therefore, it is important to realize that spillovers do not only appear in the same industry.

Javorcik (2004) presented a very important paper in order to understand the effect of multinational activity on inter-industry spillovers. She studies FDI spillovers across industries. Using Lithuanian data, she examines the correlation of FDI in downstream industries (potential buyers) and in upstream industries (potential suppliers), thus providing evidence of vertical spillovers.

She finds positive spillover effects from FDI on upstream industries (backward linkages) but no significant evidence in downstream industries (forward linkages) nor in the same industry. The strategy that she proposes is quite innovative and is very close to the one used in this paper.[6]

Blalock and Gertler (2008) use Indonesian data to find that MNE's transfer technology to suppliers in less developed countries (LDC). They also point out that the transfer of technology to upstream sectors has to be to the sector as a whole in order to prevent a hold-up problem.[7]

Moreover, if there is more technology in upstream sectors, then there is lower prices for inputs; which in turn increases the incentives for other firms to enter the sector. They find out that this increased competition results in lower prices in the sector and is thus Pareto improving.

Damijan et al. (2008) study spillover effects of FDI in ten transition economies in Europe. They find greater importance of horizontal spillovers than in previous studies and also show that the magnitude of spillover effects are affected by the absorptive capacity, size, and productivity level of the firm.

More recently, Keller (2009) examine spillovers to U.S. firms through two channels: imports and FDI. They find that FDI leads to productivity gains for domestic firms. Moreover, they find that spillovers are stronger in high-tech sectors compared to low-tech sectors. They also find that small firms benefit more from FDI than larger firms.

As mentioned above, the closest study to this one is Lopez (2008), where he studies if plants benefit from foreign technology licensing by plants in either the same industry or other industries. He finds that licensing, when it is located in upstream sectors, has a positive effect

[6] The estimation strategy in Lopez (2008) is closely related to the one used by Javorcik (2004). The strategy will be explained in detail.

[7] The technology transfer cannot be to to the supplier alone becausee then the suplier could potentially benefit from charging higher prices to the MNE. Thus the technology has to be made widely available.

on productivity for firms in downstream sectors. This might be due to lower prices offered for final goods.

On the other hand, when licensing is located in downstream sectors, it has a negative impact on the productivity of upstream sectors. The intuition behind this result is that it is possible that firms that acquire a license, are also contracting imported intermediate goods as inputs for their production process. Thus, this reduces the spillover effect for other firms in upstream sectors.

Figure 1 can be used to better understand the concept of having licenses in one sector and having productivity spillover in another one. In the explample provided, we can think of the auto industry, where there are firms that are in the downstream sector (complete manufacturing) and there are firms that are in the upstream sector (any input provider for the downstream sector, like tires).

If we look at the left hand side of the Figure, if licenses are done in the downstream sector (auto manufacturing), then it is plausible to think about transfer of technology to the upstream sector (i.e. type of tire, width, etc.). Thus there could be some spillover effects that increase the productivity of the upstream sector. Throughout this chapter I will refer to these spillovers as licenses in downstream sectors (backward linkages).

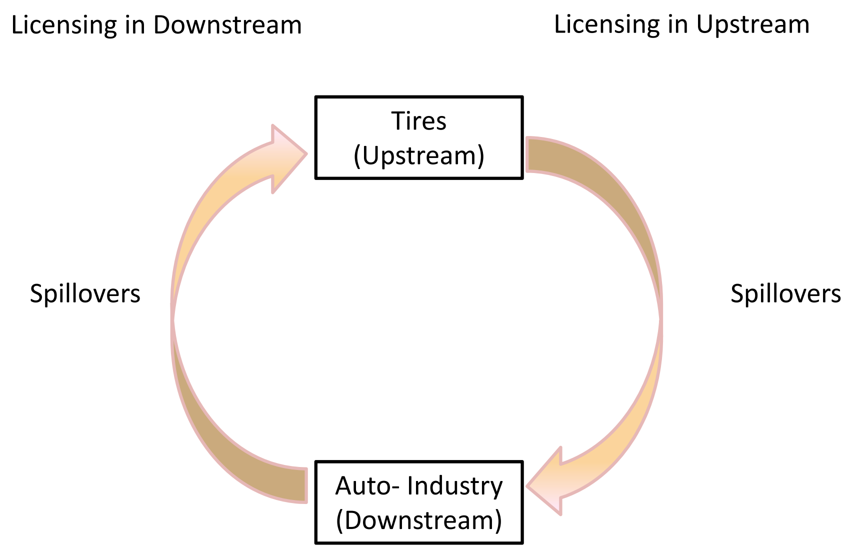
On the other hand, if there is licensing done in upstream sectors, it is possible that downstream sectors benefit through lower prices or higher quality, for example. In this case I would refer to spillovers from licenses in upstream sectors (forward linkages).

2 Data

The plant-level data used in this series of studies comes from the Chilean *Encuesta Nacional Industrial Anual* (ENIA).[8] The survey is conducted by the Chilean National Statistics Institute (INE) and it covers all the establishments (plants) with ten or more workers. The years covered by this study are 2001 - 2007.

[8] This is a national survey of the manufacturing sector.

Figure 1: Spillover Effects of Licensing



Previous versions of this census have been used by Pavcnik (2002), Lopez (2008), among others. However, they use previous periods of the census. One study that uses this census for the 2001-2006 period is Gibson and Graciano (2011).

The unit of observation is the "establishment" (plant). There are firms that only have one plant; however there are firms that have more than one plant and that are integrated either vertically or horizontally (multi-plant and also multi-activity).

In the case of multiple plants that belong to a firm, the survey includes each plant of the firm. Even though each plant has its own ID, due to statistical secrecy purposes, it is not possible to identify which plants belong to a given firm.[9] Thus, each plant has a unique ID number that allows to follow its performance throughout time, permitting longitudinal studies. In the present thesis the terms plant and firm will be interchangeable.

Regarding the activity of the plant, in order to classify the economic activity of the plant, the *International Standard Industrial Classification of All Economic Activities* (ISIC) revision

[9] This could present a problem if the majority of firms are multi-plant; however, as noted by Pavcnik (2002), using a previous version of this dataset, around 90% of the firms are uni-plant.

3 from the United Nations classification system was used.[10] The level of disaggregation of economic activities is at the four digit level.[11]

2.1 Data Cleaning

The original dataset contains 37,307. The first thing to note about the dataset is that starting in 1974 Chile was divided into 13 regions. However, in 2007 two region were split, *Tarapacá* became *Arica y Parinacota* and *Tarapacá*; and *Los Rios* became *Los Rios* and *Los Lagos*. In order to maintain the consistency of the dataset, the 1974 division is maintained throughout the sample.

Next, since all the monetary variables in the dataset are in current pesos, it is necessary to deflate them into real pesos. Two different deflators are used in this case. Since this studies rely in the estimation of Total Factor Productivity (TFP) then, for all the variables that enter the estimation of TFP, like sales I use a 4-digit deflator specifically designed by the INE for this survey. For variables that have a more macroeconomic meaning and where it makes more sense to use a wider deflator, like the value of licenses paid, or the wages, I use a more encompassing deflator, the GDP deflator, provided by the Central Bank of Chile.

Some observations were purged in the data cleaning process. First I dropped one observation where the value added for the firm was extremely high for one year. Also, it is important to note that even though there might be some negative values of value added (due to the fact that it is calculated as them production value minus intermediate goods) those observations will remain in the dataset. This could be a concern when thinking about the TFP estimation, however, as it will be clear in the estimation section, I use revenue (sales) in TFP estimation instead of value added.

The rest of observations that are purged are the firms that either change industries or

[10] See: http://unstats.un.org/unsd/cr/registry/regcst.asp?cl=2 for more detail.

[11] The covered industries are, in terms of ISIC (Rev.3) codes, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36. ISIC (Rev.3) codes of the manufacturing sector ranges from 15 to 36. Industries 16 (tobacco) and 23 (coke, refined petroleum products and nuclear fuel) have no observations in the dataset. Later, when estimating productivity, I also drop industry 30 (office machinery), which does not have enough firm-level variation.

region (location) during the period of the study. Even though it could be argued that there is a loss of information in this case, the counter argument is twofold. First, the number of observations lost is not extremely high; the number of plant-year observations purged is 1,277 (approx. 3% of the entire dataset). Second, when estimating a model using fixed effects, the main assumption is that these fixed effects will capture all the inherited characteristics of a firm that do not change over time, thus a change in industry or region would invalidate the interpretation of the results.[12] The final dataset has 36,026 plant-year observations in 111 industries.

2.2 Descriptive Statistics

Table 1 shows descriptive statistics of key variables. It is important to note that most of the stock of capital stock is held by domestic plants, while foreign firms only hold 28% of the capital on average.[13] However, this is a very high percentage when comparing to the percentage of foreign firms.

Table 1: Descriptive Statistics for Key Variables
(36,026 Obs.)

Variable	Mean	SD	Min	Max
Capital Stock	2,611	26,352	0	2,140,000
% Domesic Capital	95	20	0	100
% Foreign Capital	5	20	0	100
Value Added	3,052	26,766	-118,000	1,860,000
Sales Of Production	4,960	37,206	0	1,810,000
Payments for Licenses And Foreign Assistance	8	152	0	11,864
Income Due To Exports	1,779	17,771	0	1,020,000
Number of Skilled Workers	15	58	0	2,691
Skilled/Unskilled workers ratio	1	4	0	287
Skilled/Total workers ratio	0	0	0	1

Note: All monetary values are in 2003 Million Pesos.
Value added has negative values due to the way it is calculated which is the difference between Gross Production Value and Intermediate Consumption.

In order to determine which firms are considered foreign, I used a 10% capital rule (i.e.

[12] A more detailed explanation will be provided in the empirical section.

[13] This average is calculated for the entire sample (across industries and across time) . The calculation is not shown in Table 1 but it is available upon request.

if the foreign capital holding is more than 10% the establishment is considered foreign) the resulting differentiation is presented in table 2.

Table 2: Number of Firms by Type of Ownership
(10% capital rule)

Owner	Freq.	Percent	Cum.
Domestic	33,992	94.35	94.35
Foreign	2,034	5.65	100
Total	36,026	100	

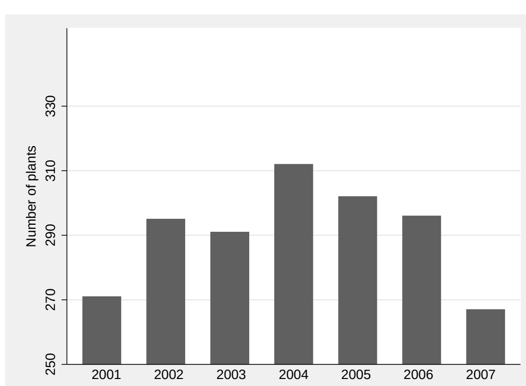
Moreover it is also possible to analyze the number of firms that operate only in the domestic market, the ones that sell to the domestic market and also export, and those that only export. This is depicted in Table 3.

Table 3: Distribution of Firms according to Market Service

Market	Freq.	Percent	Cum.
Non-exporter	28,641	79.50	79.5
Domestic and Exporter	7,101	19.71	99.21
Exporter	284	0.79	100
Total	36,026	100	

When analyzing the dynamics of foreign presence in Chile, one striking feature is depicted in the figure below, where the decline in the number of foreign plants after 2004 is extremely drastic, achieving levels in 2007 that were even lower than the ones in 2001.

Figure 2: Number of Foreign Plants



Moreover, in order to estimate TFP, the data has been grouped at the 2-digit ISIC level. To better understand the distribution of the data, it is possible to look at the number of observations and the description of each ISIC 2 group in Table B.1 in the appendix.

To better analyze the dynamics between domestic and foreign firms, as well as entry and exit, it is possible to construct transition tables where the entry and exit of foreign plants can be quantified. The average transition matrix for any two years within the 2001 - 2007 period is depicted in Table 4.

Table 4: Transition Matrix for 2001 - 2007

2001-2007					
		Period t+1			
		Domestic	Foreign	Exit	Total
Period t	Domestic	4,265	22	616	4,903
	Foreign	28	237	30	295
	Enter	591	36	0	627
	Total	4,884	294	646	

The way to interpret this matrices is as follows. Say for example we take the Domestic-Domestic cell in the matrix which shows that, on average, 4,265 firms were domestic on period t and remained domestic in period $t+1$. The Foreign-Domestic cell shows how many plants changed from foreign to domestic, and so on. The Enter row is showing how many plants entered the Chilean market in $t+1$, while the Exit column shows how many plants exited in period t.

There are a few important things to note from these transition table. First, it is clear that the average number of domestic firms has decreased in this period (this is due mostly to a decrease in the number of firms in 2007). At the same time, the number of foreign firms has stayed relatively constant (294-295). Second, the previous comment is confirmed when looking at the average number of exits for domestic firms (616) versus the average number of entrants (591).

However, a note of caution is needed here since the total number of plants (domestic and foreign) has decreased after 2004.

3 Measures of IPR

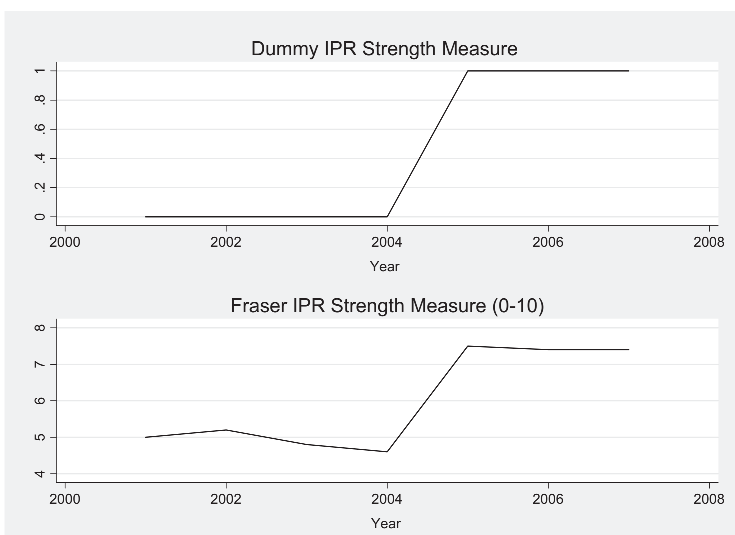
Two different measures of IPR will be used in this study, a dummy variable at the time of the change, and the Fraser index.

The dummy variable takes a value of one on and after the year of the reform (2005), and a value of zero otherwise. This is the type of measure used by Branstetter et al. (2007).

However; since the change cannot happen overnight, it is also useful to take into account a measure that comes from a survey and relates to intellectual property rights and property rights in general. Thus, the second measure of protection comes from the Fraser Institute, in the *Economic Freedom of the World* report. In this case the question asked is if "Property rights, including over financial assets are poorly defined and not protected by law (= 0) or are clearly defined and well protected by law (= 10)".[14]

The two different measures can be viewed in the graph below, note that the Fraser and the dummy measures follow the same trend so we should not expect differences when using either of them.

Figure 3: IPR Strength Measures



[14] The formula used by the Fraser institute is based in the index presented by another institution, the World Economic Forum, in it's *Global Competitiveness Report*. The relation used is: $EFW_i = [(GCR_i - 1)/6] * 10$.

4 Empirical Approach

As stated above, the spirit is very close to the one used by Lopez (2008) and Damijan et al. (2008). In order to estimate the effect of licensing on productivity through spillovers, I use the a slight modification of Lopez (2008):

$$log(TFP_{ijrt}) = \alpha_0 + \beta'\Theta_{jt} + \lambda' X_{ijrt} + \theta' Z_{jt} + \varepsilon_{ijrt} \quad (1)$$

Where i is the plant, j is the sector, r is the region and t is the time. Θ_{jt} measures foreign licensing in the same industry S_{jt} and upstream U_{jt} and downstream D_{jt} industries. X_{ijrt} is a vector of firm level controls (exporter, foreign owned, and level of licenses as fraction of sales). Z_{jt} is a vector of control variables that includes the Herfindahl index to control for concentration, the export to sales ratio of the sector and measures of foreign presence in the same industry as well in downstream industries and upstream industries.

Note that the measurement of each of these variables entails a lot of detail. In order to calculate the vector Θ_{jt}, I use the value paid by each firm for licenses and technical assistance to calculate these variables.[15] The variable is calculated as:

$$S^F_{jt} = \frac{\sum_{i \in j} Lijt}{\sum_{i \in j} Sales_{ijt}}$$

Where the assumption is that the larger the share of license payments, the larger the potential spillover effect. The downstream and upstream variables are calculated as:

$$D^F_{jt} = \sum_{k, k \neq j} \alpha_{jk} S^F_{kt}$$

$$U^F_{jt} = \sum_{k, k \neq j} \sigma_{jk} S^F_{kt}$$

Where α_{jk} is the proportion of sector j output supplied to sector k, while σ_{jk} is the share of

[15] For this variable, Lopez (2008) uses two methods, the stock method and the flow method. The method described here refers to the flow method, for a detailed explanation of both methods see Lopez (2008).

inputs purchased by sector j from sector k.

Finally, the vector Z_{jt} includes measurements of foreign presence:

$$FDI\ Same\ Sector_{jt} = \frac{\sum_{i \in j} Foreign\ Share_{ijt} * Y_{ijt}}{\sum_{i \in j} Y_{ijt}}$$

$$FDI\ Downstream\ Sector_{jt} = \sum_{k, k \neq j} \alpha_{jk} * FDI\ Same\ Sector_{kt}$$

$$FDI\ Upstream\ Sector_{jt} = \sum_{k, k \neq j} \sigma_{jk} * FDI\ Same\ Sector_{kt}$$

Where $Foreign\ Share_{ijt}$ is the percentage of foreign ownership and Y_{ijt} is the output (value added) of plant i, in industry j, and year t. The results obtained by Lopez (2008) are reported in the appendix, he finds out that licensing done in upstream sectors increases productivity of plants that purchase intermediate inputs from them (downstream sectors); while, as explained above, when licensing is done in downstream sectors, there is a negative effect on the productivity of suppliers (upstream sectors). The latter result is counterintuitive, and goes against previous results like Javorcik (2004) and Blalock and Gertler (2008) which is another reason why it is important to validate the results. Moreover, it is also very relevant to take into account the strengthening in IPR that occurred in 2005.

The first step is to estimate productivity (TFP) in order to evaluate changes in productivity due to licensing. In order to measure productivity, its possible to employ the semi-parametric method proposed by Olley and Pakes (1996) like in Damijan et al. (2008); however, since the data contains many zeros for investment, I use the modification proposed by Levinsohn and Petrin (2003) in order to overcome the investment problem and also to correct the simultaneity bias that arises when the firm knows its own productivity but it is unknown to the econometrician.

4.1 Total Factor Productivity (TFP) Estimation

As explained above, for TFP estimation, data is grouped into 2-digit sector codes (see Table B.1 in appendix). This is done due to the fact that there are not enough observations at the 4-digit or even at the 3-digit level in order to properly estimate TFP.

The main idea behind TFP estimation is to attribute to differences in productivity all the residuals from the output of the firm (either sales or value added) and the use of inputs like skilled and unskilled labor and capital. Thus, the estimating equation in this case would be:

$$log(TFP_{ijrt}) = y_{ijrt} - \alpha_1 k_{ijrt} - \alpha_2 l^s_{ijrt} - \alpha_3 l^u_{ijrt} \tag{2}$$

Where y_{ijrt} is the log of any variable that measures output (like sales) of the firm i in sector j and region r at time t; k_{ijrt} is the log of capital stock; while l^s_{ijrt} and l^u_{ijrt} are the logs of the number of skilled and unskilled workers respectively.

One might be tempted to estimate equation (2) using Ordinary Least Squares (OLS). However, as shown by Olley and Pakes (1996), some of the inputs might be chosen by the firm according to its productivity. This generates an endogeneity problem. Olley and Pakes (1996) propose using investment instead of intermediate inputs (capital) that might be chosen endogenously with productivity.

However the main limitation of this methodology is that there could be a large number of "zero" investment observations (not all firms invest every single period. Thus a lot of information is potentially lost. In order to fix this, a more robust estimator was proposed by Levinsohn and Petrin (2003). The proposed change is to use some variable that would indicate the use of intermediate inputs instead of capital in the estimation of equation (2). After estimating equation (2) for the 2001 - 2007 period, we can go back and estimate equation (1).

In this study, I estimate equation (2) using the Levinsohn and Petrin (2003) method and using skilled and unskilled labor as free variables and the value of purchased electricity as a proxy for capital. It is important to note that the Levinsohn and Petrin (2003) method can be implemented using either value added or revenue. In this case I will use sales as the output measure since there are some observations with negative value added. Moreover, since value added is calculated as production minus intermediate consumption, sales give a better estimate of the real "value" of the output of the firm in a given year. The coefficients from the Levinsohn-Petrin estimation are depicted in Table B.2 in the appendix.

4.2 Econometric Issues

After estimating TFP, as noted by Javorcik (2004) and Lopez (2008), there are a few econometric issues that have to be taken into account when estimating equation (1). First, there could be firm-level time-invariant characteristics that are not captured in the model and make some firms more productive (the most widely example used is managerial ability). Thus, it is necessary to estimate the equation in first differences.

Second, since there could be shocks at the industry or region level that affect the productivity of only one group of firms; therefore it is necessary to include a set of of two-digit ISIC sector and region dummies, as well as a time trend.

The third issue is simultaneity (more productive sectors could spend more on licensing). Thus, the entire vector Θ in equation (1) can be correlated with the error term. As discussed in Lopez (2008) this can be accounted for by using instrumental variables. In order to overcome this problem, the three licensing variables are instrumented with their first and second lags.

The final issue that we have to correct the standard errors because of the possibility of underestimating standard errors due to the estimation with firm-level data but including sector varying variables as shown by Moulton (1990). In this case we have to cluster the standard errors at the industry-year level.

It is important to note that there are crucial differences in the estimation when compared to Lopez (2008). First, the estimation of productivity is done for each 2-digit industry instead of each 3-digit industry. Second, the input-output table used in the calculation of the backward and forward coefficients is the 2003 input-output table.

5 Preliminary Results

In the estimated model, for each case there are four models. The first model uses Ordinary Least Squares - OLS - over the entire sample (Pooled OLS). The second model, takes into account the firm time-invariant characteristics and it is estimated using OLS in first differences (OLS FD). The third model takes into account the simultaneity problem, using Instrumental Variables (IV) in order to estimate the coefficients (Panel IV). The last model takes into account all the different issues and estimates the model using instrumental variables in first differences (Panel IV FD). Note that when estimating the Panel IV the first stage is also estimated in first differences.

Table C.1 is the re-estimation of the results obtained by Lopez (2008) (see the appendix for his results). The first difference with his results is that there is a strong **positive** effect of licenses in downstream sectors. That is, licenses that are paid in downstream sector have a positive effect on the productivity of upstream sectors - positive backward spillover effects; while he finds a negative effect.

This is a very interesting result that can be explained by the fact that licenses in downstream sectors could be thought as promoting the use of domestic inputs; which in turn would result in technology transfer to upstream sectors.

The magnitude of these spillover effects is very large. If there is an increase in the amount of licenses in downstream sectors equivalent to one million pesos, then the upstream sectors experience an increase of approximately 85% in productivity.

Another important difference with Lopez (2008) is that he finds positive spillovers from firms with licenses in upstream sectors to downstream sectors. Table C.1 shows no significant spillovers from licenses in upstream sectors. In this case, this could be explained by the fact that in the previous period, there was a significant *"market effect"* in the sense that firms with licenses in the upstream sector would tend to expand in the market, lowering the prices for their "consumers" and thus, making them more productive.

Moreover, the results obtained are in line with the results from Javorcik (2004). There might be a few reasons for that. First, Chile has been developing quite rapidly in the past decade, which would change its productive sector (captured by the IO table). Since in this period Chile is similar to the study of Lithuania in Javorcik (2004) it would seem plausible to infer that the degree of development of the country plays a crucial role in different spillover effects, specially inter-industry. Second, with Chilean development, also comes an increase in imitative/absorptive capacity of domestic firms. Thus, if there is "new" technology in the market, it is easier for a more developed nation to start imitating products that are either coming straight from MNE's through FDI or indirectly through licensing. It is important to note that if there is a high absorptive capacity in the host country, then that would create a positive bias in the spillover effect and it would result in an overestimation of spillover effects.[16]

Regarding the effect of stronger IPR, Table (C.2) presents the estimation with the inclusion of the Fraser IPR measure. The results confirm the signs found in table (C.1). More importantly, when looking at the effect of licensing in downstream sectors, it positive and higher than in the previous case. This goes hand-in hand with the fact that the IPR reform has a negative effect on spillovers from downstream sectors.[17]

When comparing the results to the ones obtained once the IPR measure is introduced, it is important to note that before policy, the increase in productivity was between 92% and 137%. In the case of the estimation using the Fraser Institute IPR measure, the decline in productivity in upstream sectors (licensing in downstream sectors) is around 9%. When using the dummy variable, this decline is much higher - 25%.

The magnitude of this results seem very large. This can be explained by the fact that there

[16] At this point, the assumption is that this correlation is not high enough to create a bias, but this could be checked by introducing an interaction term of the spillover effects with skilled labor, like in Damijan et al. (2008).

[17] In order to make this claim it is useful to think about the dummy IPR measure and the Fraser measure as interaction terms that reflect a difference between before and after the reform. However; this is not a Difference-in-Difference estimation since the change in IPR affects each firm in the same way.

has to be an increase of one million pesos in order to have these effects. When realizing that on average, each firm only has 8 million pesos that they pay in licenses, then one million pesos is equivalent to a 12.5% increase in licenses. Then the results obtained seem more plausible.

If we take this into account, the increase in productivity given a 1% increase in licenses is between 7.4% and 11%. Moreover, it is also important to note that less than 5% of the firms pays licenses so that change of one million pesos is also quite significant.

Therefore, it is possible to infer that introducing an IPR measure has had a negative effect for firms that are in upstream sectors and when licensing is done in downstream sectors.

This result can be explained by thinking of stronger IPR as inducing more licensing in the downstream sector and also hindering the spillover effects from those sectors. This follows the reasoning that stronger IPR, as stronger punishments in some sense, will deter firms from passing along new technology into other sectors.

Table (C.3) presents results for the Dummy IPR measure. As expected, it depicts fairly similar results to the ones in Table (C.2). Finally, Table (C.4) is a combination of the panel data IV in first differences results for the other three tables.

6 Extensions

6.1 Productivity Heterogeneity

Once the spillover effects from licenses in downstream sectors have been documented, it is possible to analyze spillover effects depending on the productivity of the firm. In this case it is possible to follow Damijan et al. (2008) and estimate equation (1) by quartile of productivity.

It is important to make this distinction, not only to analyze firm characteristics on spillover results, as explained by Damijan et al. (2008) but also because it is important to see the effect of a change in the IPR regime and its effect on different productivity level firms.

Results for the model without any IPR effects are reported in Table D.1 in the appendix. In all cases, the estimation was done using panel IV estimation. In this case, when looking at the results by quartile, it is possible to see that the spillover effect of licenses in the downstream sector increases with the level of productivity of the firm.

However, only the third and fourth quartile of productivity are statistically significant which could point out that only firms that are already above the productivity median can benefit from spillover effects. This seems quite plausible since only firms that are already productive might have the technical ability to be the suppliers of firms in the downstream sectors where the licensing is happening. In other words, firms in the downstream sector might prefer inputs from the most productive firms due to different reasons like product characteristics and level of technological complexity. Moreover, there is a significant change in the magnitude of the spillover effect, where now there is a stronger effect for high productivity firms.

The next important question is what happens when there is a change in IPR. Table D.2 depicts the results by quartile when using the Fraser IPR measure. Here we see a very interesting trend regarding spillovers from downstream sectors. In this case, all the quartiles seem to “benefit” from licensing in the downstream sector before the IPR strengthening. This is true for all the different TFP quartiles and even more pronounced for low-productivity firms.

When looking at the interaction term, it is negative for all quartiles, but it is significant only for the first quartile. This is consistent with the results presented in the previous table, since it seems that the low productivity firms are being affected the most with the IPR reform. Thus, this would be indicative that the IPR reform would impose a restriction on low productivity firms to be able to increase their productivity. Results using the dummy IPR measure are depicted in Table D.3. These results are in line with the main result of positive spillovers to upstream sectors in high productive firms.

Now, the last extension would be to try to combine the effect of productivity on spillover effects. This could be approached using a triple interaction term. In this case the equation to be estimated without the IPR reform will be:

$$log(TFP_{ijrt}) = \alpha_0 + \beta'(\Theta_{jt} \text{ x } Quartile) + \lambda' X_{ijrt} + \theta' Z_{jt} + \varepsilon_{ijrt} \quad (3)$$

Where, as before, i is the plant, j is the sector, r is the region and t is the time. Θ_{jt} measures foreign licensing in the same industry S_{jt} and upstream U_{jt} and downstream D_{jt} industries. X_{ijrt} is a vector of firm level controls (exporter, foreign owned, and level of licenses as fraction of sales). Z_{jt} is a vector of control variables that includes the Herfindahl index to control for concentration, the export to sales ratio of the sector and measures of foreign presence in the same industry as well in downstream industries and upstream industries. Moreover, in this case Θ is interacted with $Quartile$ which is a categorical variable that takes values from one to four depending on the level of productivity of the firm.

However when estimating the equation with the IPR reform, the specification is:

$$\begin{aligned} log(TFP_{ijrt}) &= \alpha_0 + \beta'(\Theta_{jt} \text{ x } Quartile) + \lambda' X_{ijrt} + \theta' Z_{jt} \\ &\quad + \Gamma'(\Theta_{jt} \text{ x } Quartile \text{ x } IPR\ measure) + \varepsilon_{ijrt} \end{aligned} \quad (4)$$

In this case, Γ' is a 3x1 vector that includes all the triple interaction terms. These are the coefficients of interest.[18] Results are presented in Table D.4. The first column is the estimation without any IPR measure, while the second and third columns include the triple interaction with the Fraser IPR measure and the Dummy IPR measure, respectively.

Regarding the first column, there is a positive spillover effect when licenses downstream are interacted with the firm's productivity quartile. Note that the magnitude of the spillover effect from downstream licenses is smaller than in the main result. This is somewhat puzzling since one would expect that with higher productivity there should be higher spillovers; however, this could be explained by the fact that when looking at each quartile of productivity, only

[18] Since this is a triple interaction term, this would almost be a Diff -in- Diff -in- Diff model; hence caution is needed when interpreting the results.

the high productivity firms have positive spillover effects.

When introducing the Fraser IPR measure, the triple interaction term is negative and significant. Moreover, the magnitude of the spillover effect is larger, implying that there was higher spillovers before the IPR reform. Lastly, the third column presents results that are quite similar to the ones in the second column, which was expected.

References

Aitken, B. J. and Harrison, A. E. (1999). Do domestic firms benefit from direct foreign investment? evidence from venezuela. *The American Economic Review*, 89(3):605–618.

Alvarez, R., Crespi, G., and Ramos, J. (2002). The impact of licenses on a "Late starter" LDC: chile in the 1990s. *World Development*, 30(8):1445–1460.

Blalock, G. and Gertler, P. J. (2008). Welfare gains from foreign direct investment through technology transfer to local suppliers. *Journal of International Economics*, 74(2):402421.

Branstetter, L. G., Fisman, R., and Foley, C. F. (2006). Do stronger intellectual property rights increase international technology transfer? empirical evidence from US Firm-Level panel data*. *Quarterly Journal of Economics*, 121(1):321–349.

Branstetter, L. G., Fisman, R., Foley, C. F., and Saggi, K. (2007). *Intellectual property rights, imitation, and foreign direct investment: Theory and evidence*. NBER.

Damijan, J. P., Rojec, M., Majcen, B., and Knell, M. (2008). Impact of firm heterogeneity on direct and spillover effects of FDI: micro evidence from ten transition countries. LICOS Discussion Paper 21808, LICOS - Centre for Institutions and Economic Performance, K.U.Leuven.

Gibson, M. and Graciano, T. (2011). Costs of starting to trade and costs of continuing to trade. *Washington State University*.

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? in search of spillovers through backward linkages. *The American Economic Review*, 94(3):605–627.

Javorcik, B. S. and Spatareanu, M. (2008). To share or not to share: Does local participation matter for spillovers from foreign direct investment? *Journal of Development Economics*, 85(1-2):194217.

Kathuria, V. (2000). Productivity spillovers from technology transfer to indian manufacturing firms. *Journal of International Development*, 12(3):343–369.

Keller, W. (2009). International trade, foreign direct investment, and technology spillovers. *National Bureau of Economic Research Working Paper Series*, No. 15442.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2):317341.

Lopez, R. A. (2008). Foreign technology licensing, productivity, and spillovers. *World Development*, 36(4):560–574.

Montalvo, J. G. and Yafeh, Y. (1994). A microeconometric analysis of technology transfer: The case of licensing agreements of japanese firms. *International Journal of Industrial Organization*, 12(2):227–244.

Moulton, B. R. (1990). An illustration of a pitfall in estimating the effects of aggregate variables on micro units. *Review of Economics and Statistics*, 72(2):334338.

Nicholson, M. W. (2002). Intellectual property rights, internalization, and technology transfer. *FTC Bureau of Economics Working Paper No. 250*.

Olley, G. S. and Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, 64(6):1263–1297. ArticleType: research-article / Full publication date: Nov., 1996 / Copyright 1996 The Econometric Society.

Park, W. G. (2008). Intellectual property rights and international innovation. *Frontiers of Economics and Globalization*, 1.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: Evidence from chilean plants. *The Review of Economic Studies*, 69(1):245.

Saggi, K., Maskus, K. E., and Puttitanum, T. (2005). *Patent rights and international technology transfer through direct investment and licensing*. International Public Goods and the Transfer of Technology under a Globalized Intellectual Property Regime, Cambridge University Press.

Smith, P. J. (2001). How do foreign patent rights affect U.S. exports, affiliate sales, and licenses? *Journal of International Economics*, 55(2):411–439.

Yang, G. and Maskus, K. E. (2001). Intellectual property rights, licensing, and innovation in an endogenous product-cycle model. *Journal of International Economics*, 53(1):169–187.

Yasar, M. and Morrison Paul, C. J. (2007). International linkages and productivity at the plant level: Foreign direct investment, exports, imports and licensing. *Journal of International Economics*, 71(2):373–388.

A Lopez (2008) Results

Table 5. *Productivity spillovers from foreign technology licensing*

	Licenses all plants—stock			Licenses all plants—flow		
	OLS (1)	FD (2)	FD-IV (3)	OLS (4)	FD (5)	FD-IV (6)
Licenses same sector (S)	−0.119	−0.047	−0.035	0.005	−0.012	−0.022
	(3.06)**	(1.66)***	(0.79)	(0.40)	(0.95)	(1.26)
Licenses downstream sectors (D)	−0.133	−0.185	−0.228	0.002	−0.141	−0.248
	(2.84)**	(4.62)**	(5.19)**	(0.05)	(4.65)**	(5.92)**
Licenses upstream sectors (U)	−0.035	0.578	0.764	−0.055	0.237	0.400
	(0.53)	(6.11)**	(6.48)**	(1.44)	(5.63)**	(6.01)**
Herfindahl index	−0.071	−0.277	−0.277	−0.130	−0.275	−0.277
	(1.31)	(6.01)**	(6.13)**	(2.28)*	(5.50)**	(5.64)**
FDI same sector	0.008	−0.003	−0.002	0.012	−0.005	−0.002
	(1.60)	(0.67)	(0.33)	(2.12)*	(1.00)	(0.43)
FDI downstream sectors	0.031	−0.015	0.024	0.030	−0.064	0.023
	(0.78)	(0.38)	(0.59)	(0.67)	(2.20)*	(0.58)
FDI upstream sectors	0.013	0.229	0.177	0.046	0.363	0.327
	(0.34)	(4.11)**	(3.01)**	(1.20)	(6.64)**	(5.46)**
Exports sector	0.032	−0.042	−0.015	−0.004	−0.075	−0.045
	(1.07)	(1.04)	(0.33)	(0.14)	(2.01)*	(1.09)
Exporter dummy	0.462	−0.013	−0.012	0.466	−0.017	−0.016
	(16.43)**	(0.77)	(0.70)	(16.51)**	(0.98)	(0.94)
Foreign ownership dummy	0.259	0.050	0.051	0.278	0.050	0.052
	(9.50)**	(1.28)	(1.31)	(9.97)**	(1.27)	(1.29)
Licenses/sales	1.613	1.345	1.346	3.866	0.494	0.465
	(7.48)**	(2.76)**	(2.77)**	(2.37)*	(1.52)	(1.41)
R-squared	0.517	0.098	0.096	0.515	0.087	0.079
Number of observations	33,821	26,740	26,740	33,821	26,740	26,740

Absolute value of *t* statistics in parentheses. **, *, ***: significant at 1%, 5%, and 10%. Three-digit sector, region, and year dummy variables were included but not reported. Standard errors were clustered at the sector-year level.

B Descriptive Statistics and TFP Estimation

Table B.1: Distribution of Firms according to Sector

ISIC rev.3 at 2-digit level	Observations	Description
15	11,217	Manufacture of food products and beverages
17	1,724	Manufacture of textiles
18	1,841	Manufacture of wearing apparel; dressing and dyeing of fur
19	938	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	2,432	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	1,050	Manufacture of paper and paper products
22	1,796	Publishing, printing and reproduction of recorded media
24	2,127	Manufacture of chemicals and chemical products
25	2,219	Manufacture of rubber and plastics products
26	1,913	Manufacture of other non-metallic mineral products
27	920	Manufacture of basic metals
28	2,567	Manufacture of fabricated metal products, except machinery and equipment
29	1,953	Manufacture of machinery and equipment n.e.c.
30	12	Manufacture of office, accounting and computing machinery
31	515	Manufacture of electrical machinery and apparatus n.e.c.
32	55	Manufacture of radio, television and communication equipment and apparatus
33	212	Manufacture of medical, precision and optical instruments, watches and clocks
34	512	Manufacture of motor vehicles, trailers and semi-trailers
35	323	Manufacture of other transport equipment
36	1,700	Manufacture of furniture; manufacturing n.e.c.

Table B.2: TFP Estimation

ln (Sales) Sector Code	15	17	18	19	20	21	22	24	25	26
No. of Observations	11217	1724	1841	938	2432	1050	1796	2127	2219	1913
ln (Skilled Labor)	**0.112**	**0.32**	**0.214**	0.024	-0.033	**0.2054**	**0.1398**	**0.3362**	**0.1537**	**0.1901**
ln (Unskilled Labor)	**0.169**	**0.33**	**0.222**	**0.36**	0.1217	**0.3465**	**0.229**	0.0455	**0.1936**	-0.02
ln (Capital)	0.164	**0.47**	0.108	0	0.4755	**0.1757**	**0.239**	0.114	0	0.042
sum of coefficients	0.445	1.12	0.544	0.384	0.5642	0.7276	0.6078	0.4957	0.3473	0.2121

ln (Sales) Sector Code	27	28	29	31	32	33	34	35	36
No. of Observations	920	2567	1953	515	55	212	512	323	1700
ln (Skilled Labor)	0.19	0.08	0.2293	**0.2646**	0.29744	0.043	**0.8389**	0.145	**0.2631**
ln (Unskilled Labor)	**0.91**	0.1214	**0.387**	**0.2489**	-0.19	0.499	**0.9726**	**1.28**	**0.3997**
ln (Capital)	0	0.2499	0	0.047	0	0.24	0.17	0	**0.1609**
sum of coefficients	1.1	0.4513	0.6163	0.5605	0.10744	0.782	1.9815	1.425	0.8237

C Preliminary Results

Table C.1: Spillover Effects of Licensing

Dependent variable: log (TFP)	(1) Pooled OLS	(2) Pooled OLS FD	(3) Panel IV	(4) Panel IV FD
Licenses same sector (S)	-0.59	-0.06	-2.04***	0.45
	(0.58)	(0.11)	(0.64)	(2.17)
Licenses downstream sectors (D)	1.14	0.21***	1.89***	0.85**
	(0.69)	(0.08)	(0.21)	(0.37)
Licenses upstream sectors (U)	0.00	0.10	2.98**	-0.53
	(0.86)	(0.21)	(1.18)	(2.46)
FDI same sector	-0.01	0.00	-0.00	-0.01
	(0.02)	(0.00)	(0.01)	(0.01)
FDI downstream sectors	0.03***	-0.00*	0.00**	0.00
	(0.01)	(0.00)	(0.00)	(0.00)
FDI upstream sectors	0.00	-0.00	0.00	0.01
	(0.02)	(0.01)	(0.01)	(0.02)
Foreign Ownership	0.47***	0.03	0.47***	0.05
	(0.04)	(0.03)	(0.05)	(0.05)
Market presence	0.42***	0.04	0.40***	0.05*
	(0.06)	(0.03)	(0.08)	(0.03)
Observations	16,428	11,500	9,619	6,357
R-squared	0.95	0.03		
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES
Number of id			3,123	2,383

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.2: Spillover Effects with Fraser IPR Measure

Dependent variable: log (TFP)	(1) Pooled OLS	(2) Pooled OLS FD	(3) Panel IV	(4) Panel IV FD
Licenses same sector (S)	-2.84***	-0.67**	-0.50	-1.07
	(0.78)	(0.33)	(0.75)	(0.81)
Licenses downstream sectors (D)	5.67***	0.40	3.08***	1.37***
	(0.76)	(0.33)	(0.61)	(0.35)
Licenses upstream sectors (U)	3.05**	0.79	1.43	1.51
	(1.21)	(0.54)	(1.31)	(1.34)
FDI same sector	0.01	0.00	0.00	-0.00
	(0.01)	(0.00)	(0.01)	(0.01)
FDI downstream sectors	0.02***	-0.00**	0.00	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
FDI upstream sectors	-0.02	-0.00	-0.00	0.00
	(0.02)	(0.01)	(0.02)	(0.01)
IPR Fraser	0.11***	0.00	0.04	-0.00
	(0.02)	(0.01)	(0.04)	(0.01)
IPR Fraser x License same sector	0.07	-0.02	0.24	0.16**
	(0.19)	(0.06)	(0.21)	(0.07)
IPR Fraser x License downstream sector	-0.81***	0.08	-0.36**	-0.09*
	(0.21)	(0.07)	(0.17)	(0.05)
IPR Fraser x License upstream sector	-0.23	-0.03	-0.69	-0.21
	(0.30)	(0.10)	(0.52)	(0.13)
Foreign Ownership	0.47***	0.03	0.45***	0.03
	(0.04)	(0.04)	(0.05)	(0.05)
Market presence	0.42***	0.04*	0.37***	0.05*
	(0.02)	(0.02)	(0.08)	(0.03)
Observations	16,428	11,500	9,619	6,357
R-squared	0.95	0.03	0.64	
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES
Number of id			3,123	2,383

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.3: Spillover Effects with Dummy IPR Measure

Dependent variable: log (TFP)	(1) Pooled OLS	(2) Pooled OLS FD	(3) Panel IV	(4) Panel IV FD
Licenses same sector (S)	-0.52	-0.12	0.56	-0.28
	(0.32)	(0.12)	(0.84)	(0.52)
Licenses downstream sectors (D)	-0.05	0.27**	1.41***	0.92***
	(0.35)	(0.13)	(0.41)	(0.17)
Licenses upstream sectors (U)	0.77	0.15	-1.78	0.49
	(0.53)	(0.21)	(1.77)	(0.86)
FDI same sector	-0.00	0.00	0.00	-0.00
	(0.01)	(0.00)	(0.01)	(0.01)
FDI downstream sectors	0.03***	-0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
FDI upstream sectors	-0.01	-0.00	-0.00	0.00
	(0.01)	(0.01)	(0.02)	(0.01)
Dummy IPR	-0.04	0.01	0.13	-0.01
	(0.05)	(0.02)	(0.12)	(0.03)
Dummy IPR x License same sector	2.16***	0.23	0.63	0.47**
	(0.38)	(0.15)	(0.53)	(0.19)
Dummy IPR x License downstream sector	-2.50***	-0.01	-1.00**	-0.25*
	(0.51)	(0.21)	(0.47)	(0.13)
Dummy IPR x License upstream sector	-1.46***	-0.30	-1.90	-0.66*
	(0.54)	(0.21)	(1.35)	(0.36)
Foreign Ownership	0.47***	0.03	0.45***	0.03
	(0.04)	(0.04)	(0.05)	(0.05)
Market presence	0.42***	0.04*	0.36***	0.05*
	(0.02)	(0.02)	(0.08)	(0.03)
Observations	16,428	11,500	9,619	6,357
R-squared	0.95	0.03		
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES
Number of id			3,123	2,383

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.4: Spillover Effects Under Different IPR Measures using Panel IV in First Differences

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Licenses same sector (S)	0.45	-1.07	-0.28
	(2.17)	(0.81)	(0.52)
Licenses downstream sectors (D)	0.85**	1.37***	0.92***
	(0.37)	(0.35)	(0.17)
Licenses upstream sectors (U)	-0.53	1.51	0.49
	(2.46)	(1.34)	(0.86)
FDI same sector	-0.01	-0.00	-0.00
	(0.01)	(0.01)	(0.01)
FDI downstream sectors	0.00	0.00*	0.00
	(0.00)	(0.00)	(0.00)
FDI upstream sectors	0.01	0.00	0.00
	(0.02)	(0.01)	(0.01)
IPR Fraser		-0.00	
		(0.01)	
IPR Fraser x License same sector		0.16**	
		(0.07)	
IPR Fraser x License downstream sector		-0.09*	
		(0.05)	
IPR Fraser x License upstream sector		-0.21	
		(0.13)	
Dummy IPR			-0.01
			(0.03)
Dummy IPR x License same sector			0.47**
			(0.19)
Dummy IPR x License downstream sector			-0.25*
			(0.13)
Dummy IPR x License upstream sector			-0.66*
			(0.36)
Foreign Ownership	0.05	0.03	0.03
	(0.05)	(0.05)	(0.05)
Market presence	0.05*	0.05*	0.05*
	(0.03)	(0.03)	(0.03)
Observations	6,357	6,357	6,357
Trend & Interaction Terms	YES	YES	YES
Industry and Region Dummies	YES	YES	YES
Number of id	2,383	2,383	2,383

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

D Extension

Table D.1: Spillover Effects by TFP Quartile with no IPR Measure

Dependent variable: log (TFP)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Licenses same sector (S)	37.78	3.24	-0.25	0.26
	(24.23)	(3.91)	(0.69)	(1.46)
Licenses downstream sectors (D)	-9.36	0.28	1.31***	1.35***
	(7.89)	(1.09)	(0.26)	(0.50)
Licenses upstream sectors (U)	-45.20	-3.65	-0.48	-0.88
	(28.12)	(4.64)	(1.06)	(2.45)
FDI same sector	-0.05*	0.00	0.02**	-0.01
	(0.02)	(0.03)	(0.01)	(0.01)
FDI downstream sectors	0.01	0.00	-0.00	0.01*
	(0.01)	(0.01)	(0.00)	(0.00)
FDI upstream sectors	0.07*	-0.01	-0.04**	0.01
	(0.04)	(0.04)	(0.02)	(0.02)
Foreign Ownership	0.29*	-0.03	-0.07	0.09
	(0.16)	(0.16)	(0.08)	(0.08)
Market presence	0.02	0.13**	0.10**	0.02
	(0.10)	(0.06)	(0.05)	(0.04)
Observations	1,321	1,560	1,619	1,857
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D.2: Spillover Effects by TFP Quartile with Fraser IPR Measure

Dependent variable: log (TFP)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Licenses same sector (S)	-5.32	2.40**	1.88	-1.28
	(4.00)	(1.18)	(1.48)	(1.10)
Licenses downstream sectors (D)	9.23***	1.86**	1.63***	1.91**
	(2.47)	(0.78)	(0.57)	(0.85)
Licenses upstream sectors (U)	7.39	-0.59	-3.71*	1.30
	(5.85)	(1.67)	(2.12)	(1.76)
FDI same sector	-0.02	0.01	0.01	-0.01
	(0.01)	(0.02)	(0.01)	(0.01)
FDI downstream sectors	0.02***	0.00	0.00	0.01***
	(0.01)	(0.00)	(0.00)	(0.00)
FDI upstream sectors	0.02	-0.01	-0.03	0.00
	(0.02)	(0.03)	(0.02)	(0.02)
IPR Fraser	-0.00	0.02	0.01	-0.02
	(0.02)	(0.02)	(0.02)	(0.03)
IPR Fraser x License same sector	-0.89	0.05	-0.07	0.28***
	(0.60)	(0.10)	(0.13)	(0.11)
IPR Fraser x License downstream sector	-1.64**	-0.28	-0.13	-0.15
	(0.77)	(0.19)	(0.08)	(0.11)
IPR Fraser x License upstream sector	1.55*	-0.29*	0.32**	-0.28
	(0.94)	(0.17)	(0.15)	(0.23)
Foreign Ownership	0.22*	-0.01	-0.06	0.07
	(0.13)	(0.16)	(0.08)	(0.07)
Market presence	0.05	0.12**	0.09*	0.01
	(0.09)	(0.06)	(0.05)	(0.04)
Observations	1,321	1,560	1,619	1,857
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D.3: Spillover Effects by TFP Quartile with Dummy IPR Measure

Dependent variable: log (TFP)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Licenses same sector (S)	-9.14*	2.66**	1.38	-0.05
	(5.17)	(1.09)	(1.23)	(0.73)
Licenses downstream sectors (D)	1.48	0.62	1.01***	1.28***
	(1.81)	(0.44)	(0.32)	(0.38)
Licenses upstream sectors (U)	14.41*	-1.95	-2.03	0.23
	(7.44)	(1.43)	(2.04)	(1.67)
FDI same sector	-0.02	0.01	0.01	-0.01
	(0.01)	(0.02)	(0.01)	(0.01)
FDI downstream sectors	0.02***	0.00	0.00	0.01***
	(0.01)	(0.00)	(0.00)	(0.00)
FDI upstream sectors	0.02	-0.01	-0.03	0.01
	(0.02)	(0.03)	(0.02)	(0.02)
Dummy IPR	-0.03	0.05	0.02	-0.04
	(0.06)	(0.05)	(0.06)	(0.07)
Dummy IPR x License same sector	-2.68	0.13	-0.18	0.79***
	(1.82)	(0.29)	(0.35)	(0.28)
Dummy IPR x License downstream sector	-4.97**	-0.73	-0.33	-0.52*
	(1.94)	(0.54)	(0.22)	(0.28)
Dummy IPR x License upstream sector	4.78*	-0.84	0.87*	-0.71
	(2.69)	(0.54)	(0.45)	(0.63)
Foreign Ownership	0.22*	-0.01	-0.06	0.07
	(0.13)	(0.16)	(0.08)	(0.07)
Market presence	0.06	0.12**	0.09*	0.01
	(0.09)	(0.06)	(0.05)	(0.04)
Observations	1,321	1,560	1,619	1,857
Trend	YES	YES	YES	YES
Industry and Region Dummies	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table D.4: Spillover Effects with Triple Interaction Term

Dependent Variable: log(tfp)	(1) No IPR	(2) Fraser IPR	(3) Dummy IPR
Licenses same sector (S) x Quartile	-0.12	-0.35***	-0.09
	(0.35)	(0.14)	(0.06)
Licenses downstream sectors (D) x Quartile	0.28***	0.73***	0.28***
	(0.09)	(0.16)	(0.09)
Licenses Upstream Sectors (U) x Quartile	0.11	0.20	0.10
	(0.57)	(0.21)	(0.10)
IPR Fraser x Licenses same sector x Quartile		0.05***	
		(0.02)	
IPR Fraser x Licenses downstream sector x Quartile		-0.10***	
		(0.02)	
IPR Fraser x Licenses upstream sector x Quartile		-0.02	
		(0.03)	
Dummy IPR x Licenses same sector x Quartile			0.15***
			(0.05)
Dummy IPR x Licenses downstream sector x Quartile			-0.26***
			(0.06)
Dummy IPR x Licenses upstream sector x Quartile			-0.07
			(0.08)
FDI same sector	-0.00	-0.01	-0.01
	(0.01)	(0.00)	(0.00)
FDI downstream sector	0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
FDI upstream sector	0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)
IPR Fraser		0.01	
		(0.01)	
Dummy IPR			0.00
			(0.03)
Quartile		0.53***	0.53***
		(0.02)	(0.02)
Foreign Ownership	0.04	0.08*	0.08*
	(0.05)	(0.04)	(0.04)
Market presence	0.05	0.04*	0.03
	(0.03)	(0.02)	(0.02)
Observations	6,357	6,357	6,357
R-squared	0.02	0.25	0.25
Trend & Interaction Terms	YES	YES	YES
Industry Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1