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Luis Castro Peñarrieta* and Gustavo Canavire-Bacarreza†

Abstract

Licensing is one of the main channels for technology transfer from foreign-owned multinational enterprises (MNEs) to domestic plants. This transfer occurs within industries and across industries, which results in technology spillovers that can affect both intra- and inter-industry productivity. We propose a theoretical model that predicts that this effect can be enhanced by the implementation of stronger intelectual property rights (IPR). Using Chilean plant-level data for the 2001–2007 period and exogenous variation from a reform in 2005, we test our theoretical predictions and find positive inter-industry effects, which result in higher productivity for domestic plants. However, there are negative spillovers when licensing is implemented within the same industry. We also test for the effect of stronger IPR and find that stronger IPR reduces intra-sector spillovers but increases inter-industry spillovers. Moreover, the IPR effect is stronger on firms that are, on average, smaller and have low productivity. Our results are robust not only to a series of definitions of IPR, licensing and productivity but also to a set of different specifications.

JEL: O34, O44, C5, K2

Keywords: Technology Licensing, Productivity, Spillovers, Chile

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I. Introduction

Productivity gaps can explain differences in economic growth across countries; numerous studies have demonstrated the importance of technology transfer to reducing the productivity gap between developed and developing nations (see, for example, Montalvo and Yafeh (1994)). While there can be many ways in which technology can be transferred from one country to another, the role of technology transfers from a multinational enterprise (MNE) has gained importance both in policy making and the academic arena, especially over the past thirty years. The main channels through which MNEs transfer technology to a host country are foreign direct investment (FDI), licensing, and imports. The importance of FDI and imports for economic growth and productivity due to the technology transfers they deliver has been shown in many studies (see, for example, Blalock and Gertler (2008), and Alfaro et al. (2006)).

Less is known about the licensing channel, especially in developing and emerging economies. Thus, we will focus on licensing as a channel for technology transfer given the importance of this channel in developing countries, which have introduced various policies to attract foreign participation. As Zanatta et al. (2008) note, clear examples of this trend are the recent economic opening of China, the amendment to the Indian Law of Patents in 2002 and the liberalization of most aspects of FDI in India.

Moreover, with the increasing importance of intangible assets in the current state of economic globalization, technology transfer, either through licensing or FDI, may be enhanced by the implementation of stronger intellectual property rights (IPR) legislation that affects the decisions of MNEs.[1] In fact, the awareness of the importance of IPR has increased over the last twenty years due to the implementation of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) in 1995 by members of the World Trade Organization (WTO). As stated by the WTO, *"it (the agreement) establishes minimum levels of protection that each government has to give to the intellectual property of fellow WTO members."*[2] Nevertheless, controversy persists over the effect of strengthening IPR on the welfare of the host economy. On one side, stronger IPR provides the protection necessary for production to shift and increase in a developing country *(the "market effect")* and thus release resources in developed countries to further advance the technological frontier. On the other side, stronger IPR reduce the ability of local firms in the host economy to imitate new technologies and create a *"monopoly effect"* that reduces the incentive for investment or licensing in the foreign affiliate.[3]

To examine the effects of licensing on productivity and the potential enhancing effect of IPR, we extend the theoretical model of Maskus et al. (2005) and test its

[1] Branstetter et al. (2006) and Branstetter et al. (2007) analyze the various effects of IPR reforms on growth and productivity in different countries.

[2] For further information, see the World Trade Organization website.

[3] Lai (1998), Yang and Maskus (2001) provide a complete discussion on the benefits of IPR.

implications using Chilean manufacturing data for the 2001–2007 period. To better identify the IPR effect, we exploit an exogenous change produced by a 2005 IPR reform in Chile that includes significant changes to IPR legislation and implementation. Therefore, this represents an extremely favorable opportunity to gauge the effect of an IPR change. There are four important contributions made in this paper. First, we propose a theoretical model that helps to understand the effects of IPR on technology transfer. Second, using data from Chile, we empirically examine the effect of a change in IPR, which might affect MNEs' choice of entry mode and, thus, the level of licensing. Third, considering the new developments in the field of productivity measurement, this study uses a different and more accurate productivity estimation technique compared to earlier studies. Fourth, it is possible to determine different magnitudes of spillover effects depending on the productivity level of the firm as in Damijan et al. (2008).

Our results show that increasing the strength of patent laws in Chile led to smaller backward spillover effects in the economy. This may primarily be because stricter and better-enforced laws reduce incentives for people to copy foreign technology when they may face a stronger penalty for doing so. Moreover, the IPR policy seemed to *"harm"* firms with lower productivity and smaller firms, which may have benefited more from spillover effects.

The remainder of the paper is structured as follows. Section two provides some foundations and presents our theoretical model that motivates the empirical study. Details about the data used are explained in section four, while the empirical strategy and analysis are reported in sections five and six. Section seven concludes the paper.

II. Where do we stand? A Brief Review of the Existing Literature

Our conceptual framework is based on the established literature on technological transfer and property rights to explain the enhancing effect of IPR on the spillover effects of licensing on productivity.

As Maskus et al. (2005) note, MNEs have the choice to transfer technology through FDI or licensing. This transfer of technology may be enhanced (or reduced) by various factors and conditions such as the institutional capacity of the host country and the country's legal structure and IPR (Yang and Maskus (2001) and Canavire et al. (2017)); this last factor raises the cost of imitation in the host country; thus, it increases both modes of entry. Moreover, as argued by Yang and Maskus (2001), increasing IPR allows for higher levels of licensing since it is easier to enforce existing contracts.

The dearth of quality evidence on the effects of licensing on productivity has fueled the general debate regarding the potential spillover effects of licensing on firm productivity, as most of the evidence has focused on FDI effects. In fact, the consistent evidence of the positive spillover effects of FDI attracted the attention to the benefits of this mode of entering a market, which sometimes dulls the potential effects of licensing, especially in developing and emerging economies. Javorcik (2004a) and Damijan et al. (2008), contribute to the understanding of the effects of multinational activity on inter-industry spillovers. Using Lithuanian data and European data, they find positive spillover effects from FDI on upstream industries (backward spillover effects) but no significant evidence in downstream industries (forward spillover effects) or within the same industry.

However, as Kathuria (2000) notes, most studies that examine spillover effects might be underestimating the effect of foreign presence if they treat FDI as the sole channel for spillovers. Alvarez et al. (2002) find that local spending on licensing has a high level of return. Thus, the "investment" made in licensing improved the performance and productivity of Chilean firms during the 1990s. Moreover, as noted by Lopez (2008), the effects of licensing do not only apply to the same industry; there are also inter-industry effects. Therefore, it is important to realize that spillovers do not only appear in the same industry. As Blalock and Gertler (2008) argue, the transfer of technology to upstream sectors has to be to the sector as a whole to prevent a hold-up problem.[4] Moreover, if there is more technology in upstream sectors, then there are lower input prices, which in turn increase the incentives for other firms to enter the sector. Those authors report that this increased competition results in lower prices in the sector and is thus Pareto improving.

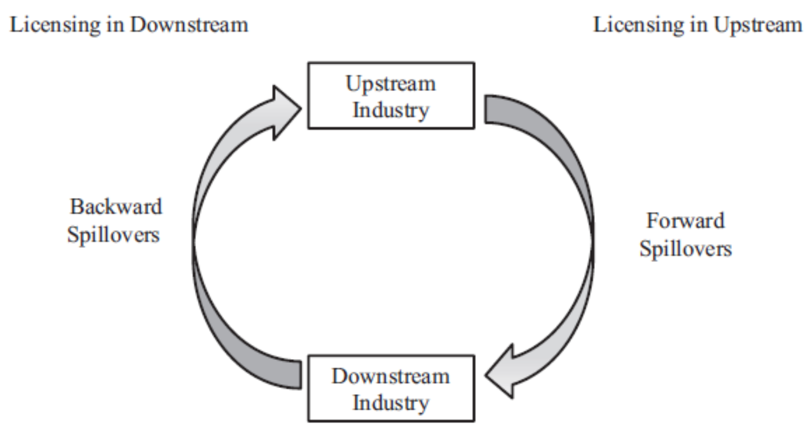
As mentioned above, the closest study to ours is Lopez (2008), who studies whether plants benefit from foreign technology licensing by plants in either the same industry or in other industries. He finds that licensing, when it is located in upstream sectors, has a positive effect on productivity for firms in downstream sectors. This might be due to lower prices being offered for final goods. However, 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 to their production process. Thus, this reduces the spillover effect for other firms in upstream sectors.

We can use figure 1 to better understand the concept of having licenses in one sector while having productivity spillovers in another sector. One example of the possibility for spillovers is the US MNE *GNC Live Well*, which offers pharmaceutical products in Chile (vitamins, diet supplements, etc.). This MNE has issued 115 different licensees in Chile to make various products. In this case, the licensees can be a source of backward spillovers since they could potentially use generic products produced by local firms as inputs. Moreover, this particular example could also be a source of forward linkages, as GNC could provide chemical components to other firms and induce an increase in their productivity. Another example of spillovers for the Chilean economy is the US MNE *Burger King*, which produces fast food. This MNE has been in Chile for 11 years and issued 22 different licensees. In this case, it is likely that licensee firms in Chile use

[4] A technology transfer cannot be to to the supplier alone because the supplier could then potentially benefit from charging higher prices to the MNE. Thus the technology has to be made widely available.

intermediates from Chilean providers, such as food and beverages from local providers, packing containers of a given quality and so forth. This could create backward spillovers in the economy.[5] Similarly, the Canadian MNE *Bubble Gummers* produces apparel for children. This MNE has been in Chile for 32 years, with 42 different stores licensed to sell products with its branding. Here, licensee firms in Chile use intermediates such as cotton of a given quality or rubber for the soles of shoes.

Figure 1: Spillover Effects of Licensing



From the left-hand side of the figure, we observe that if licenses are issued in the downstream sector (auto manufacturing), then it is plausible to imagine technology transfer 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 paper, we will refer to these spillovers as licenses in downstream sectors (backward linkages).

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

III. Theoretical Framework

Our theoretical model is an extension of that presented by Maskus et al. (2005). Their original model concerns a multinational's choice of entry mode (either through FDI or licensing) in which an MNE has to be indifferent between FDI and licensing. Thus, after the entry decision has been made, there are two types of firms in the host economy that have a direct link with the MNE: FDI firms and licensees.

We argue that it is necessary to introduce linkages that can produce backward spillovers in the host economy. Bringing in such linkages, and thus the possibility of

[5] For further examples, see www.franquicia.cl/nacionales.html

intra-industry spillovers, requires an intermediate good industry. Following Markusen and Venables (1999), there are three types of firms in the host country: domestic suppliers of intermediate goods (p_i, x_i), foreign firms that undertake FDI (p_i^*, x_i^*), and domestic firms that receive licenses (p_L, x_L). In addition, there are also firms located abroad that produce intermediate goods, which can be used in the host economy but only through either FDI or licensing (p_F, x_F). Following Maskus et al. (2005), the fixed cost of production for firms in the final goods industry takes the following form:

$$F_j = K_j + c_j(k) \qquad \text{for } j = F, L$$

Where K_j are production-related costs (independent of IPR), and $c_j(k)$ is a contractual cost that depends on the strength of IPR (k). Since it is plausible to think that MNEs incur higher fixed costs through the need to establish distribution channels, gain knowledge of the market, and so forth, it is assumed that $F_F > F_L$. Following Yang and Maskus (2001), we assume that the contractual costs of both FDI and licensing decline with the level of IPR, that is: $\frac{dc_j}{dk} < 0$. However, it is reasonable to suppose that these costs decline with k faster for licensing than for FDI:

$$\left|\frac{dc_F(k)}{dk}\right| < \left|\frac{dc_L(k)}{dk}\right|$$

This is a plausible assumption because licensees have a comparative advantage relative to FDI firms since they have greater knowledge of the contract enforcement mechanisms in the host country.

III.I Technology

Let FDI and licensing firms have a constant returns to scale (CRS) Cobb-Douglas production function, using labor and intermediate goods in the host country as inputs:

$$x_j = l_j^{1-\alpha} q_j^{\alpha} \qquad \text{for } j = L, F$$

Where l_j is labor, and q_j is a composite intermediate input that also requires labor (following Dixit and Stiglitz (1977) and Ethier (1982)). The production function of intermediate goods is assumed to be a CES function that uses intermediate goods from the domestic economy and from abroad.

$$q_j = \left[\mu_j(k) x_{ij}^{\theta} + (1 - \mu_j(k)) x_{ij}^{*\,\theta}\right]^{1/\theta}$$

Where θ is the elasticity of substitution between intermediate goods, x_{ij} is the amount of intermediate goods (either domestic or imported) needed to produce a unit of good j, and there is an efficiency parameter $\mu(k)$ that represents the efficiency of domestic inputs. The crucial link between IPR strength and the efficiency parameter is that when there is stronger IPR, it is plausible that both FDI and licensing firms have access to greater varieties of intermediate inputs (which might even be better in terms of quality); thus, the relative efficiency of domestic intermediate goods is reduced.

It is also plausible to assume that FDI firms have greater access to intermediates from the home country. That is, $\mu_F < \mu_L$. Furthermore, an increase in IPR strength negatively affects the requirement for domestic goods, as explained above (firms will transfer more goods from abroad); thus, $\frac{d\mu_j(k)}{dk} < 0$. Here again it seems likely that an increase in IPR will affect FDI firms more than licensing firms, perhaps because MNEs access a greater range of intermediate goods that could be sent to the host country. Thus we assume the following:

$$\left|\frac{d\mu_F(k)}{dk}\right| > \left|\frac{d\mu_L(k)}{dk}\right|$$

The operating profit function is given by

$$\begin{aligned}\pi_j =& p_j x_j - p_i x_{ij} - p_i^* x_{ij}^* - w l_j \qquad \text{for } j = L, F \\ \pi_j =& p_j l_j^{1-\alpha}\left[\mu_j(k) x_{ij}^{\theta} + (1-\mu_j(k)) x_{ij}^{*\,\theta}\right]^{\alpha/\theta} - p_i x_{ij} - p_i^* x_{ij}^* - w l_j \end{aligned} \tag{1}$$

III.II Decision between FDI and licensing and spillover effects

As Maskus et al. (2005) note, new technology brought into the country either by FDI or licensing has two inherent risks. First, any technology could be supplanted by a newer technology through innovation competition. In particular, if there is a large pool of potential innovators and their innovation incentives are unchanged by changes in IPR in the host country, then it is appropriate to assume that successful innovation follows a Poisson process with arrival parameter i. Second, technology can be imitated in the host country. This is equally likely for FDI and licensing. We assume that successful imitation also follows a Poisson process with arrival parameter $m(k)$, where $\frac{dm}{dk} < 0$. That is, having stronger IPR reduces the rate of imitation.

MNEs choose between FDI and licensing, which means that a firm must be indifferent between these alternatives in equilibrium. Thus, the operating profits from FDI are higher than those from licensing to compensate for the higher fixed cost of FDI. Thus, $\pi_F > \pi_L$. To more carefully demonstrate this equilibrium, we need to compare the discounted value of assets in the two cases. With a discount rate equal to r, we have

$$V_F = \frac{\pi_F}{i + m(k) + r} - F_F \qquad \text{and} \qquad V_L = \frac{\pi_L}{i + m(k) + r} - F_L$$

The firm will engage in FDI if $V_F > V_L$. Then, the indifference point occurs where $V_F - V_L = 0$:

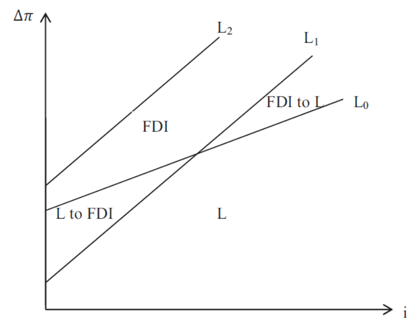
$$\frac{\pi_F}{i + m(k) + r} - F_F = \frac{\pi_L}{i + m(k) + r} - F_L \tag{2}$$

Equation (2) can be written as follows:

$$\Delta\pi = (i + m(k) + r)\Delta F(k) = (m(k) + r)\Delta F(k) + i\Delta F(k) \tag{3}$$

Where $\Delta\pi = \pi_F - \pi_L > 0$, and $\Delta F(k) = F_F(k) - F_L(k) > 0$. Note that equation (3) is a straight line in the $\Delta\pi, i$ plane with intercept $(m(k) + r)\Delta F(k)$ and slope $\Delta F(k)$. This line is depicted as L_0 in figure 2. Consider a point above L_0, that is, $\delta\pi > 0$. Thus,

Figure 2: FDI and Licensing Decision with Variable Innovation



Source: Maskus et al. (2005).

$\pi_F > \pi_L$, and it is more profitable for the MNE to enter the host economy through FDI. That is, if the firm is above L_0, then it will choose FDI over licensing. However, if the firm is below L_0, it will choose licensing over FDI.

Now consider the impact of strengthening IPR on the choice between FDI and licensing. In this case, Maskus et al. (2005) report two direct effects. First, it will affect the slope of the line L_0, and second, it will affect the intercept of this line. However, in the current model, there will be a third effect due to the presence of IPR in the operational profit function:

$$\frac{d(\pi_F - \pi_L)}{dk} = \frac{d((m(k) + r)\Delta F(k))}{dk} + \frac{id\Delta F(k)}{dk} \tag{4}$$

First, the cost of imitation increases and the rate of imitation $m(k)$ would decline. Second, the fixed costs of both FDI and licensing would decline. However, the reduction would be greater for licensing since we assume the following:

$$\left|\frac{dc_F(k)}{dk}\right| < \left|\frac{dc_L(k)}{dk}\right| \qquad \Rightarrow \qquad \frac{d\Delta F}{dk} = \frac{dc_F}{dk} - \frac{dc_L}{dk} > 0$$

Third, for the LHS of (1), we have

$$\frac{d(\pi_F - \pi_L)}{dk} = \frac{d\pi_F}{dk} - \frac{d\pi_L}{dk}$$

Since the only terms included here that have (k) in them are related to the domestic and foreign intermediate input requirements, $\frac{d(\pi_F - \pi_L)}{dk}$ would give the effect on backward spillovers of a change in IPR. Thus, for $\frac{d\pi_F}{dk}$, we have

$$\begin{aligned}\frac{d\pi_F}{dk} =& p_F l_F^{(1-\alpha)} \frac{\alpha}{\theta} \left[\mu_F(k) x_{iF}^{\theta} + (1-\mu_F(k)) x_{iF}^{*\theta}\right]^{(\alpha-\theta)/\theta} \frac{d\mu_F(k)}{dk} x_{iF}^{\theta} - \frac{d\mu_F(k)}{dk} x_{iF}^{*\theta} \\ =& \Omega_F \frac{d\mu_F(k)}{dk} \left(x_{iF}^{\theta} - x_{iF}^{*\theta}\right)\end{aligned}$$

Where

$$\Omega_F = p_F l_F^{(1-\alpha)} \frac{\alpha}{\theta} \left[\mu_F(k) x_{iF}^{\theta} + (1-\mu_F(k)) x_{iF}^{*\theta}\right]^{(\alpha-\theta)/\theta} > 0$$

Therefore,

$$\frac{d\pi_F}{dk} = \Omega_F \frac{d\mu_F(k)}{dk} \left(x_{iF}^{\theta} - x_{iF}^{*\theta}\right) \gtrless 0 \qquad \text{and} \qquad \frac{d\pi_L}{dk} = \Omega_L \frac{d\mu_L(k)}{dk} \left(x_{iL}^{\theta} - x_{iL}^{*\theta}\right) \gtrless 0$$

The term $\frac{d(\pi_F - \pi_L)}{dk}$ could therefore be either positive or negative. The intuition is as follows. If this term is positive, it would mean that having stronger IPR leads to an increase in $\Delta\pi = \pi_F - \pi_L$. Then, it is more profitable to engage in FDI than in licensing. As a result, there will be a strongly negative effect on the demand for domestic intermediate goods, as FDI firms now demand lower levels of domestic intermediate inputs. In turn, there would be smaller backward spillovers.

If $\frac{d(\pi_F - \pi_L)}{dk}$ is negative, FDI would be less profitable than licensing and the latter would rise. However, this outcome would also imply a negative effect on the demand for domestic intermediate goods, which leads to smaller backward spillovers. However, the effect would be smaller than in the previous case.

Moreover, the sign also depends on the change in the equilibrium quantities of intermediates used. In this case, it is possible to assume that the equilibrium quantity of domestic intermediates decreases with stronger IPR while the quantity of foreign intermediates increases.

To determine the sign of the LHS of (4), note that

$$sign\left(\frac{d(\pi_F - \pi_L)}{dk}\right) = sign\left(\frac{d((m(k)+r)\Delta F(k) + i\Delta F(k))}{dk}\right) \tag{5}$$

Note that the RHS of (4) can be decomposed into the effect on the slope and the effect on the intercept. The effect on the slope is clear:

$$\frac{id\Delta F(k)}{dk} = i\left(\frac{dc_F}{dk} - \frac{dc_L}{dk}\right) > 0$$

Thus, an increase in IPR would unambiguously increase the slope of line L_0 depicted in figure 2, say, to that shown in line L_1. When examining the effect on the intercept, we need to consider two cases. It is possible that the decline in costs is dominated by the reduction in imitation:

$$\frac{d((m+r)\Delta F)}{dk} = \frac{dm}{dk} + (m+r)\frac{d\Delta F}{dk} < 0$$

As noted in Maskus et al. (2005), in this case, the indifference line between FDI and licensing would shift downward and would also be steeper. Thus, the new line lies below the old line for low rates of innovation (low-tech industries) and above the line for high rates of innovation (high-tech industries). The result is that increasing IPR converts licensing to FDI for low innovation rates but shifts FDI to licensing for high innovation rates (line L_1 in figure 2).

In the second case, it is possible that the decline in relative costs dominates the reduction in imitation:

$$\frac{d((m+r)\Delta F)}{dk} > 0$$

Here, the line shifts up and is steeper (line L_2 in figure 2). Therefore, increasing IPR unambiguously induces firms to increase licensing, regardless of the rate of innovation.

Therefore, there will be two hypotheses to be tested regarding the impacts of an increase in IPR. The first is the effect on backward spillovers to domestic firms through licensing, and the second is that the magnitude of spillovers can depend on a firm's productivity.

Initially, licensing implies greater demand for domestic intermediate inputs, which should result in higher productivity. However, as a result of stronger IPR, there should be a decrease in backward spillovers.

IV. Data

As previously stated, the firm-level data used in this series of studies come from the Chilean *Encuesta Nacional Industrial Anual* (ENIA).[6] The survey is conducted by the Chilean National Statistics Institute (INE) and covers all establishments (plants) with ten or more workers. The years covered by this study are 2001–2007.

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 multi-activity). In the case of multiple plants that belong to a firm, the survey includes each of these plants. Although each plant has its own identification number (ID), due to statistical confidentiality purposes, it is not possible to identify which plants belong to a given firm.[7] Thus, each

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

[7] 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, approximately 90% of the firms have a single plant. For the 2001-–2007 period, this figure is approximately 89%.

plant has a unique ID number that allows one to follow its performance over time, thus permitting longitudinal studies. In the present paper, the terms plant and firm will be used interchangeably. However, we will generally refer to establishments as firms. Regarding the activity of firms, to classify the economic activity of the plant, we use the *International Standard Industrial Classification of All Economic Activities* (ISIC) revision 3 from the United Nations classification system. The level of disaggregation of economic activities is at the four-digit level[8]; however, due to data constraints, this study focuses on two-digit aggregation.[9]

Data cleaning: The original dataset contains 37,307 firm-year observations, but some observations were purged in the data cleaning process. First, firms with negative value added have been purged from the study. Second, three different industries have been excluded. Industry 27 at the two-digit level ISIC level (Manufacture of Basic Metals) has been dropped from the study because the prices for these products are guided mainly by international prices. This implies that such variables as value added and sales for these products do not reflect the relationship between inputs and output. Industries 30 and 32 (Manufacture of office, accounting and computing machinery and Manufacture of radio, television and communication equipment, respectively) have been dropped from the study since there are not enough observations in each case (11 and 51 for the entire sample, respectively) to have enough variation to properly estimate productivity. To estimate TFP, the data have been grouped at the two-digit ISIC level. To better understand the distribution of the data, please find the number of observations and the description of each industry in table 11 in the Appendix. Note that except for the Food and Beverages industry, the observations are fairly evenly distributed. The rest of the observations that are purged are the firms that changed either industries or regions (locations) during the period of the study. Although 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 large (approximately 6 percent of the original dataset). Second, when estimating a model using fixed effects, 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. We deflate the entire dataset to reflect constant prices. The final dataset has 33,538 firm-year observations in 17 industries at the two-digit level.

IV.I Descriptive statistics

Table 1 shows descriptive statistics of key variables. It is important to note the high heterogeneity among the firms in the dataset. On the one hand, there are firms with

[8]See http://unstats.un.org/unsd/cr/registry/regcst.asp?cl=2 for further details.

[9]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, and 36. The ISIC (Rev.3) codes of the manufacturing sector range from 15 to 36. Industries 16 (tobacco) and 23 (coke, refined petroleum products and nuclear fuel) have no observations in the dataset.

capital stock equal to zero, while other firms' capital stock reaches 953,000 million pesos. In addition, most of the stock of capital is held by domestic firms, and value added reaches, on average, 2,342 million pesos with a standard deviation of 19,274.[10]. To determine which firms are considered foreign, we used a 10-percent capital rule (i.e., if the capital holding is more than 10 percent, the establishment is considered foreign). Nearly 94 percent of the firms are domestic, and only approximately 6 percent are foreign. We observe a similar result when we examine the structure of firms that pay licenses: 95 percent of firms do not pay licenses, while 5 percent do.

Table 1: Descriptive Statistics for Key Variables

Variable	Mean	Std. Dev.	Min	Max
Capital Stock	1,946	15,532.6	0	953,000
% Domestic Capital	96	19.3	0	100
% Foreign Capital	4	19.3	0	100
Value Added	2,342	19,274.8	0	1,720,000
Sales of Production	3,815	29,328.1	0	1,770,000
Total Wages	375	2,148.9	0	275,000
Gross Production Value	5,449	46,237.2	2	3,480,000
Payments for Licenses and Foreign Assistance	8	151.3	0	11,864
Income due to Exports	1.090	8,654.9	0	401,000
Number of Skilled Workers	13	46.4	0	1,554
Skilled/Unskilled Workers Ratio	1	3.5	0	159
Skilled/Total Workers Ratio	0	0.3	0	1

Notes: 1) We use 33,538 Obs. 2) All monetary values are in millions of 2003 pesos.

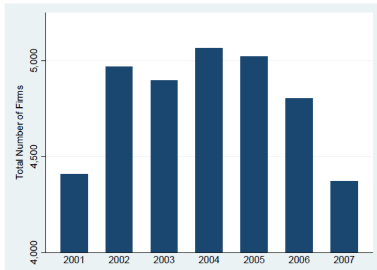
Moreover, when analyzing the dynamics of the number of firms present in Chile, one striking feature is depicted in figure 3, in which the decline in the number of firms after 2005 is extreme, achieving levels in 2007 that were even lower than those in 2001. This is not the case solely for domestic firms; it seems that FDI in the manufacturing sector has declined steadily in recent years.

To better analyze the dynamics between firms that undertake licensing, it is possible to construct transition tables between 2001 and 2007. (table 2). In this case, it is clear that the number of firms that do not pay licenses decreased slightly during this period (again, this is most likely due to a decrease in the total number of firms in 2007). However, the number of firms that pay licenses increased. Again, note the slight increase in the percentage of firms that pay licenses in period t + 1, rising from 4.4% to 4.5%.

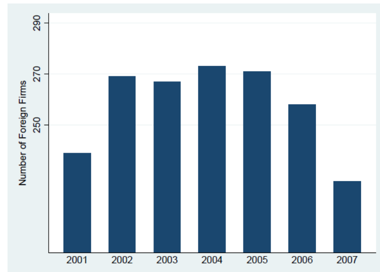
[10]The average exchange rate in 2003 was 691.54 pesos per US dollar.

Figure 3: Number of Firms

(a) Total



(b) Foreign



(c) Licensing

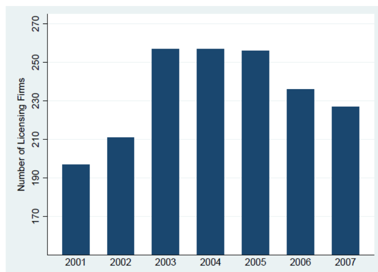


Table 2: Transition Matrix for 2001-–2007

		2001-2007			
		Period t+1			
		No Licensing	Licensing	Exit	Total
Period t	No Licensing	75.2%	1.5%	9.4%	86.0%
	Licensing	1.4%	2.6%	0.4%	4.4%
	Enter	9.2%	0.4%	0.0%	9.6%
	Total	85.8%	4.5%	9.7%	100.0%

IV.II IPR Reforms and Measures

IPR reform in Chile: Since technology transfer can be affected by the implementation of intellectual property rights (IPR), it is helpful to understand the concept and the reform that happened in Chile in 2005. Intellectual property, in a very broad sense, is everything that is created by the human mind, such as inventions, branding, and literary works. However, in Chile, the term intellectual property is related *specifically* to one branch of intellectual property, which are copyright laws for authors [11].

[11]In Chile, IPR encompasses industrial property, including patents, commercial branding, origin denominations (controlled by the National Institute of Industrial Property (INAPI)), and copyright law, relating to artists, and performers regarding their work, recordings, radio and TV shows (controlled by the Office of Intellectual Property Right)

In this paper, we will focus more on the role of INAPI since it is the *"...technical and legislative office in charge of the administration and attention of the services of Industrial Property..."* Thus, one of the principal roles of INAPI is to regulate the registry of IP rights[12]. While there have been some laws on IP dating back to the Chilean constitution, Law No. 19,996 of March 11, 2005, was a comprehensive law that made significant changes to the concept of brands, the process of requirements for securing patents, brand registration, and the time limit for patents (set to 20 years). It also included new fees to be paid for patenting and branding. Moreover, one of the most important changes in the law was the creation of an Industrial Property Tribunal (Art. 17 of Law 19,996). This is an independent special court, subject to the Supreme Court, which sits in the city of Santiago and has power over IPR-related disputes. All these changes increased IPR in Chile, increased the enforcement of IP laws and reduced the contracting costs related to technology transfer. Moreover, the increase in the number of years allowed for a patent created an incentive to increase technology transfer to Chile.

Measures of IPR: Given the above and the characteristics of the available data, two different measures of IPR are used, a dummy variable at the time of the change and the Fraser index. The dummy variable takes a value of one in 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 such 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 whether "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)[13]".

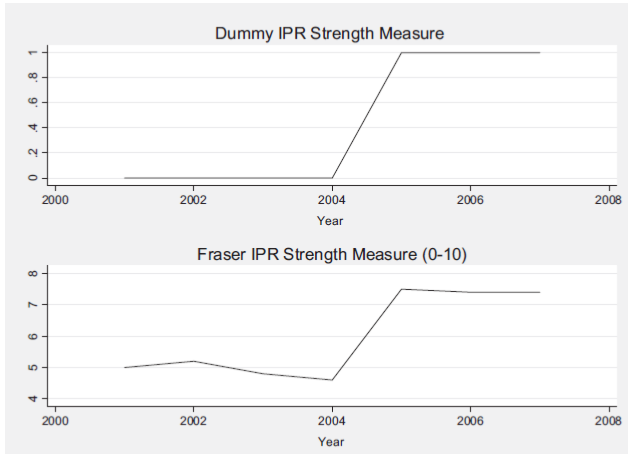
Note that the Fraser Institute measure of IPR, as the survey indicates, includes a wider measure of property rights, not only including a specific intellectual property rights measure but also a more general property rights measure, which also includes assets.

The two different measures can be viewed in figure 4; note that the Fraser and dummy measures follow the same trend, and thus, we should not expect differences between the results obtained when using either of them.

[12] For further information, see Instituto Nacional de Propiedad Industrial (www.inapi.cl).

[13] The formula used by the Fraser institute is based in the index presented by another institution, the World Economic Forum, in its *Global Competitiveness* Report. The formula used is $EFWi = [(GCRi - 1)/6] * 10$.

Figure 4: IPR Strength Measures



V. Empirical Approach

As presented in our theoretical framework, there can be spillover effects derived from licensing that affect productivity and can be enhanced (or reduced) by strengthening (or relaxing) IPR. Thus, the aim of our empirical strategy is to disentangle those effects. The first step is to estimate total factor productivity (TFP) to evaluate changes in productivity due to licensing. To measure TFP, it is possible to employ the semi-parametric method proposed by Olley and Pakes (1996), as used in Damijan et al. (2008). Since the data contain many zeros for investment, the modification proposed by Levinsohn and Petrin (2003) should be employed to overcome the investment problem and to correct for the bias that is created.[14]

Nevertheless, a new development in TFP estimation is proposed by Ackerberg et al. (2006). They show that there is a collinearity problem when using either of the methods described above. Therefore, in this study, we will use their proposed method of estimation and perform robustness checks with the previous estimation methods.

V.I Spillover Effects

As stated above, our spirit is very close to that of Lopez (2008) and Damijan et al. (2008). To estimate the effect of licensing on productivity through spillovers, we use a slight modification of Lopez (2008):

$$log(TFP_{ijrt}) = \alpha + \beta' V_{jt} + \Gamma' X_{ijrt} + \Theta' Z_{jt} + \varepsilon_{ijrt} \tag{6}$$

Where i is the plant, j is the sector, r is the region and t is the year. V_{jt} is a

[14] This refers to the simultaneity bias that arises because not all inputs are exogenous to a firm's productivity. For a more detailed explanation, see Appendix C.

vector that comes in three forms: it measures spillovers through the same industry (horizontal linkages - H_{jt}); spillovers through backward linkages (B_{jt}); and spillovers through forward linkages (F_{jt}). X_{ijrt} is a vector of firm-level controls (exporter, foreign owned). Finally, 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.

If we rewrite the full specification of this equation, we have

$$\begin{aligned} log(TFP_{ijrt}) =& \alpha_0 + \alpha_j + \alpha_r + \alpha_t + \beta_1 H_{jt} + \beta_2 B_{jt} + \beta_3 F_{jt} \\ &+ \gamma_1 M_{ijrt} + \gamma_2 O_{ijrt} \\ &+ \theta_1 FDIS_{jt} + \theta_2 FDID_{jt} + \theta_3 FDIU_{jt} \\ &+ \theta_4 Herf_{jt} + \theta_5 Exp_{jt} + \varepsilon_{ijrt} \end{aligned} \tag{7}$$

Where α_j is a set of industry dummies; α_r is a set of region dummies; α_t is a set of time dummies; H_{jt} are horizontal spillovers; B_{jt} are backward spillovers; F_{jt} are forward spillovers; M_{ijrt} is the market presence of the firm (domestic, exporter, or both); O_{ijrt} is the ownership of the firm; $FDIS_{jt}$ is FDI in the same industry; $FDID_{jt}$ is FDI in downstream industries; $FDIU_{jt}$ is FDI in upstream industries; $Herf_{jt}$ is the Herfindahl Index; and Exp_{jt} is the exports to sales ratio by industry.

Moreover, if we want to include the effect of the IPR reform, the full specification becomes

$$\begin{aligned} log(TFP_{ijrt}) =& \alpha_0 + \alpha_j + \alpha_r + \alpha_t + \beta_1 H_{jt} + \beta_2 B_{jt} + \beta_3 F_{jt} \\ &+ \beta_4 H_{jt} \times IPR_t + \beta_5 B_{jt} \times IPR_t + \beta_6 F_{jt} \times IPR_t \\ &+ \gamma_1 M_{ijrt} + \gamma_2 O_{ijrt} \\ &+ \theta_1 FDIS_{jt} + \theta_2 FDID_{jt} + \theta_3 FDIU_{jt} \\ &+ \theta_4 Herf_{jt} + \theta_5 Exp_{jt} + \varepsilon_{ijrt} \end{aligned} \tag{8}$$

The measurement of each of these variables entails considerable detail. To calculate the vector V_{jt}, we use the value paid by each firm for licenses and technical assistance to calculate these variables.[15] The variable is calculated as follows:

$$H_{jt} = \frac{\sum_{i \in j} L_{ijt}}{\sum_{i \in j} Sales_{ijt}} \tag{9}$$

Where the assumption is that the larger the share of license payments is, the larger

[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).

the potential spillover effect. The backward spillover and forward spillover variables are calculated as follows:

$$B_{jt} = \sum_{k,k\neq j} \alpha_{jk} H_{kt} \tag{10}$$

$$F_{jt} = \sum_{k,k\neq j} \sigma_{jk} H_{kt} \tag{11}$$

Where α_{jk} is the proportion of sector j's output supplied to sector k, while σ_{jk} is the share of inputs purchased by sector j from sector k.

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

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

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

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

Here, $Foreign\ Share_{ijt}$ 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 reports that licensing to upstream sectors increases the productivity of plants that purchase intermediate inputs from them (downstream sectors); however, as explained above, licensing to downstream sectors generates a negative effect on the productivity of suppliers (upstream sectors). The latter result goes against previous results, such as those in Javorcik (2004a) and Blalock and Gertler (2008). This is another reason that it is important to validate the results. Moreover, it is key to take into account the strengthening of IPR that occurred in 2005.

VI. Econometric issues

After estimating TFP, as noted by Javorcik (2004a) and Lopez (2008), there are a few econometric issues that have to be taken into account when estimating equation (6). First, there could be firm-level time-invariant characteristics that are not captured by the model and make some firms more productive (the most widely used example is managerial ability). Thus, it is necessary to estimate the equation in first differences. The resulting equation is equation (12).

$$\Delta log(TFP_{ijrt}) = \alpha_1 + \beta' \Delta V_{jt} + \Gamma' \Delta X_{ijrt} + \Theta' \Delta Z_{jt} + \Delta\varepsilon_{ijrt} \tag{12}$$

In the full specification, this translates to

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_1 \Delta H_{jt} + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_4 \Delta (H_{jt} \times IPR_t) \\ & + \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) + \gamma_1 \Delta M_{ijrt} \\ & + \gamma_2 \Delta O_{ijrt} + \theta_1 \Delta FDIS_{jt} + \theta_2 \Delta FDID_{jt} \\ & + \theta_3 \Delta FDIU_{jt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned} \tag{13}$$

The second issue is that 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 two-digit ISIC sector and region dummies, as well as a set of time dummies.[16]

The third issue is simultaneity (more productive sectors could spend more on licensing). Thus, the entire vector V_{jt} in equation (12) could be correlated with the error term. As discussed in Lopez (2008), this can be accounted for by using instrumental variables. To overcome this problem, the three licensing variables are instrumented with their second and third lags. This is also an important difference with Lopez (2008) since the first lag of the licensing variables is not a valid instrument due to the model being estimated in first differences.[17]

The final issue is that we have to correct the standard errors because of the possibility of underestimating them because our estimation uses firm-level data but includes variables that vary by sector, 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 relative to Lopez (2008). First, the estimation of productivity is done for each two-digit industry instead of each three-digit industry. Second, the input-output table used in the calculation of the backward and forward coefficients is the 2003 input-output table.

VII. Identification

The first step in identifying the model was taken by checking the underidentification test and the overidentification test for the main three estimations of equation (13).

Another important aspect to check is the first stage of the three main estimations. The summary results for the first-stage regressions are presented in tables 3, 4, and 5.

[16] Importantly, note that due to econometric constraints, it is not possible to include this many dummies while simultaneously calculating the standard errors using clustering at the industry-year level; thus, one way to overcome this issue is to drop all firms that changed either region or industry, as explained previously.

[17] For a more detailed discussion see Cameron and Trivedi (2005) p.754.

Table 3: First-Stage Results No IPR Measure

Summary results for first-stage regressions				
Variable	Shea Partial R2	Partial R2	F(6, 50)	P-value
Horizontal Spillovers	0.4617	0.4533	22.47	0.0000
Backward Spillovers	0.4163	0.301	12.82	0.0000
Forward Spillovers	0.3263	0.3511	21.89	0.0000

Table 4: First-Stage Results Fraser IPR Measure

Summary results for first-stage regressions				
Variable	Shea Partial R2	Partial R2	F(12, 50)	P-value
Horizontal Spillovers	0.7079	0.5639	27.68	0.0000
Backward Spillovers	0.8040	0.4627	16.78	0.0000
Forward Spillovers	0.7016	0.4392	31.87	0.0000
IPR Fraser x Horizontal Spillovers	0.9190	0.5524	25.53	0.0000
IPR Fraser x Backward Spillovers	0.9320	0.4536	21.84	0.0000
IPR Fraser x Forward Spillovers	0.9025	0.4204	20.62	0.0000

Table 5: First-Stage Results Dummy IPR Measure

Summary results for first-stage regressions				
Variable	Shea Partial R2	Partial R2	F(12, 50)	P-value
Horizontal Spillovers	0.5520	0.5707	26.25	0.0000
Backward Spillovers	0.6540	0.4655	15.66	0.0000
Forward Spillovers	0.5005	0.4484	32.69	0.0000
Dummy IPR x Horizontal Spillovers	0.9250	0.6726	61.61	0.0000
Dummy IPR x Backward Spillovers	0.9314	0.6144	72.69	0.0000
Dummy IPR x Forward Spillovers	0.8982	0.6072	31.86	0.0000

Several results are presented in the above tables: Shea's partial R-squared, which takes into account the correlation between instruments; the regular R-squared between the instruments and the endogenous regressors; and the F test of the excluded instruments in the corresponding first-stage regression.

The "rule of thumb" is that the F test should be greater than 10 if the instruments are "strong."[18] This is the case in all the first-stage regressions in this study, which is a very reassuring result when considering the number of instruments needed in each regression. Since all the first-stage regressions seem to work reasonably well, it is possible to consider the second-stage estimation as in the previous section.

VIII. Results

In the estimated model for equation (13), for each case (no IPR measure, Fraser measure, and dummy variable measure), there are four estimation methods. The first method uses Ordinary Least Squares –OLS– over the entire sample (Pooled OLS). The second method takes into account the firm-level time-invariant characteristics and is estimated using OLS in first differences (OLS FD). The third method takes into account the simultaneity problem, using Instrumental Variables (IV) to estimate the coefficients (Panel IV).The last method takes into account all the different issues and estimates the model using instrumental variables in first differences (Panel IV FD). Since the Panel IV in first differences estimation is the appropriate estimation method, its results are those provided in this paper [19].

Moreover, note that in every specification of the model without the IPR reform, the sample is reduced because if we use the entire sample, it would be misspecified since there was an IPR reform in 2005. The results are presented in Table 6.

For the estimation without the IPR change, if the estimation is performed using the entire sample, this would cause a misspecification issue, as we know that there was a change in 2005. Therefore, the estimation is done using only the 2001-–2004 period. One difference with the results obtained by Lopez (2008) is that there is strong **positive** evidence of backward spillovers, while he finds a negative effect.

This is a very interesting result that can be explained by the fact that these spillovers could be thought of as promoting the use of domestic inputs, which in turn would result in technology transfer to upstream sectors. Moreover, the results show no significant forward spillovers.

These results are in line with Javorcik (2004a) in the sense of foreign presence having the same effect on domestic firms. There might be a few reasons for this finding. First, Chile has been developing quite rapidly in the past decade, which would change its productive sector (captured by the IO table). Since in the period considered, Chile is

[18] This was motivated initially by Staiger and Stock (1997) and updated by Stock and Yogo (2002).

[19] The other estimation methods have been calculated and are available from the author upon request.

Table 6: Spillover Effects Under Different IPR Measures (Panel IV in First Differences)

Dependent variable: Iog (TFP)	No IPR	Fraser IPR	Dummy IPR
Horizontal Spillovers	-1.57	0.05	-0.07
	(1.37)	(0.57)	(0.28)
Backward Spillovers	4.85***	2.66***	1.20***
	(1.13)	(0.72)	(0.46)
Forward Spillovers	-0.70	-1.33	-0.19
	(2.24)	(0.81)	(0.48)
IPR Fraser		-0.54**	
		(0.23)	
IPR Fraser x Horizontal Spillovers		-0.02	
		(0.07)	
IPR Fraser x Backward Spillovers		-0.31***	
		(0.10)	
IPR Fraser x Forward Spillovers		0.23**	
		(0.09)	
Dummy IPR			0.11***
			(0.04)
Dummy IPR x Horizontal Spillovers			-0.09
			(0.21)
Dummy IPR x Backward Spillovers			-0.87***
			(0.29)
Dummy IPR x Forward Spillovers			0.71**
			(0.28)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	0.26	0.38	0.40
Observations	2,884	8,932	8,932
Time, Industry and Region Dummies	YES	YES	YES

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

similar to Lithuania as studied in Javorcik (2004a), it would seem plausible to infer that a country's degree of development plays a crucial role in different spillover effects, especially inter-industry spillovers.

Second, the development of the Chilean economy entails an increase in the 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 MNEs through FDI or indirectly through licensing. It is important to note that if there is a high degree of imitation in the host country, then that would create a positive bias in the spillover effect since the spillover effect would not exclusively capture spillover effects through any type of learning from foreign technology (i.e., learning from exporting), and this would result in an overestimation of the spillover effects[20].

Regarding the effect of stronger IPR, the results in table 6 show that when using the Fraser IPR measure and the dummy IPR measure, backward spillovers are smaller after the reform[21].

When comparing the results once the IPR measure is introduced, it is important to note that before the policy change, the increase in productivity was between 2.7% and 1.2%. In the case of the estimation using the Fraser Institute IPR measure, the decline in backward spillovers is approximately 0.3%. When using the dummy variable, this decline is much higher (0.9%).

Finally, it is important to note that all the tables containing results include the probabilities of rejection (p-values) of two important tests: the Kleibergen-Paap LM statistic, which tests for underidentification with the null hypothesis being that the model is not identified. The second test is the Hansen J statistic for overidentification, with the null hypothesis being that the instruments are valid.

Therefore, it is possible to infer that introducing an IPR measure had a negative effect on backward linkages. Furthermore, there is a positive effect of the policy reform on forward linkages.

The first result can be explained by regarding stronger IPR as stronger punishments in some sense and that they will deter firms from passing along new technology into backward industries. The second result can be explained in the case in which the market is fairly competitive, as this would mean that introducing stronger IPR measures would induce larger forward linkages, which could be due to lower prices for downstream industries.

[20] Here, the assumption is that this imitative capacity is not high enough to create bias, but this could be checked by introducing an interaction term of the spillover effects with skilled labor, as in Damijan et al. (2008).

[21] To make this claim, it is useful to consider the dummy IPR measure and the Fraser measure as interaction terms that reflect the 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.

Note that this positive effect of the reform on forward spillovers is a very interesting result. In both cases, for the Fraser Institute measure and the dummy variable, this term is positive and significant. This represents the fact that although firms did not initially face forward spillover effects, after the IPR reform, they tend to induce higher productivity in downstream industries. One example of this could be any intermediate goods industry that after the IPR reform had a large *"market effect"* and thus increased production, and this would decrease the price for inputs in downstream industries. Again, in this case, the effect is much stronger under the dummy variable than under the Fraser Institute measure.

IX. Extensions

IX.I Productivity heterogeneity

As Damijan et al. (2008) show, the magnitude of backward spillovers can depend on the productivity of the firm. Thus, since the backward linkage effects of licenses have been established, it is possible to analyze the same effects depending on the productivity of the firm. Following Damijan et al. (2008), it is possible to divide the sample into different quartiles of productivity and estimate equation (13).[22]

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

The results for the model without any IPR effects are reported in table 7. In all cases, the estimation was performed using Panel IV in first differences. In this case, when examining the results by quartile, it is possible to see that there are significant backward linkages for firms in the lower quartiles but not for high-productivity firms. One reason for this may be that low-productivity firms have room to benefit from new technology, while high-productivity firms already have "high-end" technology and do not benefit from spillover effects.

The next question is what happens when there is a change in IPR. table 8 depicts the results by quartile when using the Fraser IPR measure and confirms the results above in the sense that lower-productivity firms benefit more than high-productivity firms. Thus, there seems to be stronger backward linkages for low-productivity firms.

The interaction term is negative for all quartiles and significant for all the quartiles except the third. Moreover, the firms that are most affected by the introduction of the IPR reform are again the least-productive firms. This is consistent with the results presented in the previous table, as it seems that low-productivity firms are highly affected

[22] It is important to note that the decision to split the sample into quartiles makes it possible to estimate the model. If the division were into smaller bins, there would not be enough observations in each group for the estimation.

by the IPR reform. Thus, this indicates that the IPR reform imposed a restriction on low-productivity firms to enable an increase in their productivity. The results using the dummy IPR measure are depicted in table 9. These results are in line with the main result of positive backward linkages and a negative effect of the IPR reform.

Another important result when analyzing productivity quartiles is that there is evidence of negative forward linkages for low-productivity firms, which was not present in the result for the entire sample. These negative forward linkages for low-productivity firms could be explained by the fact that, as those firms do not possess "high-end" technology, it might be the case that they are not able to fully reap the benefits of new inputs.

Table 7: Spillover Effects by TFP Quartile with no IPR Measure

Dependent variable: log (TFP)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Horizontal Spillovers	5.71	3.04	-5.22*	-0.71
	(8.00)	(4.30)	(2.68)	(4.99)
Backward Spillovers	19.50*	11.16**	10.84	10.04
	(10.16)	(5.48)	(6.76)	(15.60)
Forward Spillovers	-17.78	-11.39*	3.02	-5.10
	(12.30)	(6.51)	(4.32)	(6.25)
Foreign Ownership	-0.08	-0.04	-0.20**	0.22
	(0.49)	(0.08)	(0.09)	(0.28)
Market presence	-0.00	-0.17**	-0.05	-0.07
	(0.27)	(0.07)	(0.05)	(0.12)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	n/a	n/a	n/a	n/a
Observations	797	828	851	876
Time, Industry and Region Dummies	YES	YES	YES	YES

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

In this case, the interaction term is positive, which would indicate that stronger IPR benefit firms. As explained previously, this could be the case when the market is competitive. Thus, this increase in productivity may be reflected in lower prices for downstream industries. Similar results are obtained when analyzing the dummy IPR measure.

IX.II Size heterogeneity

Damijan et al. (2008) also demonstrate the importance of firm size in determining the magnitude of spillover effects. Thus, it is also possible to analyze spillover effects depending on the size of the firm through the estimation of equation (13) by quartile

Table 8: Spillover Effects by TFP Quartile with Fraser IPR Measure

Dependent variable: log (TFP)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Horizontal Spillovers	3.71*	1.20	1.02	-1.93***
	(2.10)	(1.20)	(0.79)	(0.52)
Backward Spillovers	11.20***	6.46***	0.74	5.91***
	(3.81)	(2.08)	(1.36)	(1.17)
Forward Spillovers	-10.85***	-4.68***	-1.96*	-0.54
	(2.55)	(1.75)	(1.12)	(1.15)
FDI same sector	0.03	-0.02*	0.01	0.01
	(0.02)	(0.01)	(0.02)	(0.02)
FDI downstream sectors	0.01	0.02	-0.02	0.00
	(0.04)	(0.02)	(0.02)	(0.02)
FDI upstream sectors	-0.04	0.01	-0.00	-0.02*
	(0.03)	(0.01)	(0.01)	(0.01)
IPR Fraser	-1.20	-0.48	-0.19	-1.26*
	(0.92)	(0.42)	(0.42)	(0.66)
IPR Fraser x Horizontal Spillovers	-0.24	0.07	-0.13	0.21***
	(0.23)	(0.12)	(0.08)	(0.05)
IPR Fraser x Backward Spillovers	-1.41**	-0.79**	-0.13	-0.63***
	(0.56)	(0.31)	(0.17)	(0.14)
IPR Fraser x Forward Spillovers	1.15***	0.19	0.26**	0.35***
	(0.22)	(0.16)	(0.12)	(0.13)
Foreign Ownership	-0.04	0.07	0.12	0.04
	(0.19)	(0.10)	(0.18)	(0.06)
Market presence	-0.43**	-0.14**	0.07	-0.03
	(0.17)	(0.07)	(0.05)	(0.05)
Kleibergen-Paap P-value	0.00	0.00	0.00	0.00
Hansen J Statistic P-value	0.12	0.41	0.81	0.76
Observations	1,818	2,240	2,355	2,519
Time, Industry and Region Dummies	YES	YES	YES	YES

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 9: Spillover Effects by TFP Quartile with Dummy IPR Measure

Dependent variable: log (TF'P)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Horizontal Spillovers	2.62*	1.54*	0.48	-0.95***
	(1.37)	(0.82)	(0.50)	(0.36)
Backward Spillovers	4.52**	2.79***	-0.02	3.10**
	(1.94)	(0.94)	(0.98)	(1.23)
Forward Spillovers	-5.35***	-3.73***	-0.81	0.98
	(1.90)	(1.20)	(0.76)	(1.30)
FDI same sector	0.03	-0.02*	0.01	0.01
	(0.02)	(0.01)	(0.02)	(0.01)
FDI downstream sectors	0.01	0.02	-0.02	0.00
	(0.04)	(0.02)	(0.02)	(0.02)
FDI upstream sectors	-0.04	0.01	-0.00	-0.02*
	(0.03)	(0.01)	(0.01)	(0.01)
Dummy IPR	0.19	0.20***	0.11	0.12
	(0.16)	(0.08)	(0.08)	(0.09)
Dummy IPR x Horizontal Spillovers	-0.76	0.17	-0.42*	0.62***
	(0.63)	(0.33)	(0.24)	(0.15)
Dummy IPR x Backward Spillovers	-4.07***	-2.23**	-0.37	-1.88***
	(1.57)	(0.89)	(0.49)	(0.40)
Dummy IPR x Forward Spillovers	3.35***	0.59	0.83**	1.03***
	(0.60)	(0.47)	(0.34)	(0.36)
Foreign Ownership	-0.03	0.07	0.13	0.04
	(0.18)	(0.10)	(0.18)	(0.06)
Market presence	-0.44**	-0.14*	0.06	-0.03
	(0.17)	(0.07)	(0.05)	(0.05)
Kleibergen-Paap P-value	0.00	0.00	0.00	0.00
Hansen J Statistic P-value	0.12	0.50	0.81	0.76
Observations	1,818	2,240	2,355	2,519
R-squared	0.03	0.02	0.01	-0.01
Time, Industry and Region Dummies	YES	YES	YES	YES

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

depending on firm size, as measured by the total number of workers. The results obtained in this estimation are very close to the productivity results in the previous section. The results for the model without any IPR effects are reported in table **??**.

Table **??** depicts the results by quartile when using the Fraser IPR measure. Here, we observe a very interesting trend regarding spillovers from downstream sectors. In this case, similar to productivity, all the smaller firms seem to "benefit" more from backward linkages before the strengthening of IPR. Furthermore, the interaction term is negative for all quartiles.

The results using the dummy IPR measure are depicted in table **??**. These results are in line with the main result of positive backward linkages, mainly in smaller firms.

IX.III Issues with firms exiting the market

As depicted in figure 3, there has been a clear decline in the number of firms in the manufacturing sector in Chile since 2005. The change in the number of firms could be due to a number of reasons, such as i) changes in how firms report their status (transitioning from manufacturing to service industries, for example); ii) mergers and acquisitions; and iii) decline in certain activities such as textiles and shoe manufacturing, among others.

One main concern might be that this decline is driving the results. To determine whether this is the case, it is possible to perform the analysis while restricting the sample to a balanced panel; in so doing, we would be considering only firms that remained in the market for the entire period.

The results are depicted in table 10 and confirm the previous results. Note that the decline in the total number of manufacturing firms is not affecting the results. Therefore, when considering only a balanced panel, we obtain the same qualitative results as in table 6.

IX.IV Specification Issues

Since equation equation (13) has three different terms that are derived essentially from the horizontal linkages equation, equation (9), where H_{jt} depends on the level of licenses paid in one industry, it is conceivable that there is a high correlation between this variable and the backward spillover effects variable B_{jt} and the forward spillover effects variable F_{jt}.[23]

To ensure that this plausible correlation does not affect the results, four different specifications will be tested: one in which there is no foreign presence; one in which there are no horizontal spillover effects; one in which there is no foreign presence or horizontal

[23] Recall from equations equation (10) and (11) that these two variables are H_{jt} relative to the IO table.

Table 10: Spillover Effects Under Different IPR Measures

(Balanced Panel IV in First Differences)

Dependent variable: log (TPF)	No IPR	Fraser IPR	Dummy IPR
Horizontal Spillovers	-3.14***	0.20	0.12
	(1.13)	(0.67)	(0.33)
Backward Spillovers	6.12***	2.28***	0.93*
	(1.58)	(0.85)	(0.51)
Forward Spillovers	0.41	-1.89**	-0.70
	(1.62)	(0.91)	(0.52)
IPR Fraser		-0.48*	
		(0.27)	
IPR Fraser x Horizontal Spillovers		-0.02	
		(0.09)	
IPR Fraser x Backward Spillovers		-0.29**	
		(0.12)	
IPR Fraser x Forward Spillovers		0.25**	
		(0.11)	
Dummy IPR			0.14***
			(0.04)
Dummy IPR x Horizontal Spillovers			-0.07
			(0.25)
Dummy IPR x Backward Spillovers			-0.82**
			(0.36)
Dummy PR x Forward Spillovers			0.74**
			(0.31)
Kleibergen-Paap P-value	0.00	0.00	0.00
Hansen J Statistic P-value	0.11	0.28	0.28
Observations	2,409	7,227	7,227
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

spillover effects; and finally one in which there is a different use of instrumental variables. All the results are depicted in the Appendix. Recall that the original specification was

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_1 \Delta H_{jt} + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_4 \Delta (H_{jt} \times IPR_t) \\ &+ \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) + \gamma_1 \Delta M_{ijrt} \\ &+ \gamma_2 \Delta O_{ijrt} + \theta_1 \Delta FDIS_{jt} + \theta_2 \Delta FDID_{jt} \\ &+ \theta_3 \Delta FDIU_{jt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned}$$

Where H_{jt} are horizontal spillovers; B_{jt} are backward spillovers; F_{jt} are forward spillovers; M_{ijrt} is the market presence of the firm (domestic, exporter, or both); O_{ijrt} is the ownership of the firm; $FDIS_{jt}$ is FDI in the same industry; $FDID_{jt}$ is FDI in downstream industries; $FDIU_{jt}$ is FDI in upstream industries; $Herf_{jt}$ is the Herfindahl index; and Exp_{jt} is the exports-to-sales ratio by industry.

IX.IV.1 No foreign presence

In this case, equation (13) is replaced by

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_1 \Delta H_{jt} + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_4 \Delta (H_{jt} \times IPR_t) \\ &+ \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) + \gamma_1 \Delta M_{ijrt} \\ &+ \gamma_2 \Delta O_{ijrt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned} \tag{14}$$

Table 6 reports the results for the unbalanced panel. When examining these results, positive backward spillovers are confirmed. Moreover, the IPR reform exhibits a negative impact on those spillovers.

Moreover, when using a balanced panel in this case, as depicted in table 15 in the Appendix, the results regarding the IPR reform are confirmed. However, the coefficient on backward spillovers tends to be non significant, but still positive.

IX.IV.2 No horizontal spillover effects

In this case, equation (13) is replaced by

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) \\ &+ \gamma_1 \Delta M_{ijrt} + \gamma_2 \Delta O_{ijrt} + \theta_1 \Delta FDIS_{jt} + \theta_2 \Delta FDID_{jt} \\ &+ \theta_3 \Delta FDIU_{jt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned} \tag{15}$$

The results for the unbalanced panel are depicted in table 17. When analyzing these results, positive backward spillovers remain, and the IPR reform had a negative effect on those spillovers.

Note that there seems to be a negative forward spillover effect, which was not present before. Furthermore, there is evidence of a positive effect of the IPR reform on forward spillovers. When using a balanced panel, as depicted in table 17, the results regarding the IPR reform are confirmed.

IX.IV.3 No foreign presence or horizontal spillover effects

In this case, equation (13) is replaced by

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) \\ &+ \gamma_1 \Delta M_{ijrt} + \gamma_2 \Delta O_{ijrt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned} \tag{16}$$

Table 15 displays results for the unbalanced panel. Positive backward spillovers are still evident, and the IPR reform negatively affects these spillovers.

Again, a negative forward spillover effect, which was not present before, is now evident. Furthermore, the IPR reform positively affects forward spillovers. When using a balanced panel, as depicted in table 19, the results regarding the IPR reform are confirmed.

IX.IV.4 Different use of IV

Another check that we can perform is to use the following equation:

$$\begin{aligned}\Delta log(TFP_{ijrt}) =& \alpha_1 + \beta_2 \Delta B_{jt} + \beta_3 \Delta F_{jt} + \beta_5 \Delta (B_{jt} \times IPR_t) + \beta_6 \Delta (F_{jt} \times IPR_t) \\ &+ \gamma_1 \Delta M_{ijrt} + \gamma_2 \Delta O_{ijrt} + \theta_4 \Delta Herf_{jt} + \theta_5 \Delta Exp_{jt} + \Delta \varepsilon_{ijrt}\end{aligned} \tag{17}$$

However, now there is a major difference with the previous case since the *horizontal linkage* variables are not used as instruments. The results for the unbalanced panel are depicted in table 20. When analyzing these results, positive backward spillovers remain, and the IPR reform had a negative effect on those spillover effects.

Again, note that there seems to be a negative forward spillover effect, which was not present before. Furthermore, there is evidence of a positive effect of the IPR reform on these spillovers. When using a balanced panel, as depicted in table 21, the results regarding the IPR reform are confirmed.

X. Conclusions

The importance of technological transfer for economic growth has been emphasized throughout the economics literature. Moreover, developing countries rely on licensing and FDI as sources of technology transfer and innovation. Thus, it is important to clarify the most effective channels through which a developing country can benefit from technological advancements in developed countries.

Thus, this study sheds some light on the importance of licensing as a technology diffusion mechanism. Using a dataset that contains more than 33,000 firm-year observations, we provide empirical evidence of the existence of backward spillover effects from licensing in Chile during the 2001–2007 period.

Due to the implementation of reform that strengthened IPR in Chile in 2005, it is possible to analyze the effect that this change had on how technology diffuses within and across industries. To do so, we used two different measures of IPR, and we also used the Chilean 2003 input-output table to capture the linkages between sectors.

The main contribution of this paper is to show how different economic policies can affect different sectors of the economy. In this case, it was possible to show that increasing the strength of IPR leads to smaller backward linkages, reducing the spillover effects in the economy. With stricter and better-enforced laws, there are fewer incentives for people to transfer technology when a penalty may be incurred.

Another contribution is to control for firm heterogeneity in productivity and in size to analyze different effects for different sub-samples of the survey. The results obtained, at least with the full sample, provide evidence that low-productivity and smaller firms, which formerly benefitted more from spillover effects, now suffer more from the change in IPR policy. This is in line with the results obtained by Keller and Yeaple (2009). The negative impact of stronger IPR in these cases is of greater magnitude than when compared to mid- or high-productivity firms.

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Appendix

A. Descriptive statistics

Table 11: Distribution of Firms according to Sector

ISIC rev.3 at 2-digit level	Observations	Percent	Description
15	10,764	32.09	Manufacture of food products and beverages
17	1,656	4.94	Manufacture of textiles
18	1,773	5.29	Manufacture of wearing apparel; dressing and dyeing of fur
19	883	2.63	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	2,320	6.92	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	1,026	3.06	Manufacture of paper and paper products
22	1,716	5.12	Publishing, printing and reproduction of recorded media
24	2,033	6.06	Manufacture of chemicals and chemical products
25	2,144	6.39	Manufacture of rubber and plastics products
26	1,816	5.41	Manufacture of other non-metallic mineral products
28	2,473	7.37	Manufacture of fabricated metal products, except machinery and equipment
29	1,844	5.5	Manufacture of machinery and equipment n.e.c.
31	499	1.49	Manufacture of electrical machinery and apparatus n.e.c.
33	205	0.61	Manufacture of medical, precision and optical instruments, watches and clocks
34	482	1.44	Manufacture of motor vehicles, trailers and semi-trailers
35	296	0.88	Manufacture of other transport equipment
36	1,608	4.79	Manufacture of furniture; manufacturing n.e.c.

B. Spillovers: results from Lopez (2008).

Table 12: 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.

C. TFP estimation

Following Van Beveren (2012), the most common functional form for the output is to assume a Cobb-Douglas production function. Thus, the estimating equation, would be:

$$Y_{ijrt} = A_{ijrt} K_{ijrt}^{\beta_k} L^{s^{\beta_{ls}}}_{ijrt} L^{u^{\beta_{lu}}}_{ijrt} \tag{18}$$

Where Y_{ijrt} is output of the firm i in sector j and region r at time t; K_{ijrt} is the capital stock; while L^s and L^u are the number of skilled and unskilled workers respectively. If we apply logarithms to this equation we get:

$$y_{ijrt} = \beta_0 + \beta_k k_{ijrt} + \beta_{ls} l^s_{ijrt} + \beta_{lu} l^u_{ijrt} + \varepsilon_{ijrt} \tag{19}$$

So that productivity is:

$$ln\ TFP_{ijrt} = y_{ijrt} - \beta_k k_{ijrt} - \beta_{ls} l^s_{ijrt} - \beta_{lu} l^u_{ijrt} \tag{20}$$

Which can also be seen as:

$$ln\ A_{ijrt} = \beta_0 + \varepsilon_{ijrt}$$

It is important to note that ε_{ijrt} is the time-industry-region-producer specific productivity shock, which can be decomposed into an observable part and an unobservable component. Therefore we have:

$$ln\ A_{ijrt} = \beta_0 + \nu_{ijrt} + \eta_{ijrt}$$

So that productivity is $\omega_{ijrt} = \beta_0 + \nu ijrt$ and η_{ijrt} is an i.i.d. error component. It is important to note that ν_{ijrt} is a part of the error term that is observed by the firm but not by the econometrician.

One might be tempted to estimate equation (19) using Ordinary Least Squares (OLS). However, there are several methodological issues that have to be taken into account to estimate equation (19). If we were to specify the issues one by one, we would see possible solutions.

C.I Endogeneity

If we would estimate equation (19) using OLS, the main assumption would be that all the inputs in the production function are exogenous. However, as noted by Marschak and Andrews (1944) inputs in the production function are not chosen independently. The clearest case is that any firm would determine their labor inputs according to its productivity, and thus creating a correlation between the level of inputs chosen and the productivity shock that is observed by the firm but not by the econometrician.

Thus, if the firm has knowledge of ω_{ijrt}, it would affect the choice of inputs. If there is a positive productivity shock, this would likely increase the use of variable inputs (unskilled and skilled labor), which in turn would introduce an upward bias to the estimates of variable input coefficients and a downward bias on fixed input coefficients (capital).

C.II Selection bias

The problem of selection bias is introduced when, in an unbalanced panel of firms, the decision on allocation of inputs (especially variable inputs) is not independent of the decision to continue operating in the market. Therefore, the estimation technique has to take into account that the estimates are conditional on the survival of the firm.

There are many theoretical models that predict the importance of productivity on the firm's decision to continue operating in the market. Therefore, if firms have some knowledge of their productivity, this would generate a negative bias on the capital stock coefficient. This bias is due to the fact that firms with higher capital stock and a given productivity are more likely to survive than firms with low capital stock and the same productivity level.[24]

C.III Estimation

There have been many different ways to approach the problems outlined above. The most important ways to estimate will be explained in turn. This part follows closely the work of Van Biesebroeck (2003), Van Biesebroeck (2007), and Van Beveren (2012).[25]

In the following subsections we will use a typical Cobb-Douglas production function so that there is only one type of labor (this is only a simplification that helps explain the different methods of estimation). Thus, the production process is assumed to be:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} \tag{21}$$

C.III.1 Index numbers

This approach does not rely on a functional form of the production function. It relies on a theoretical approach to estimate the relation between inputs and output without the necessity to specify an exact production function. The basic idea of this approach is to calculate the following formula:

$$\begin{aligned} log\ (A_{it}/A_{it-1}) &= log\,(Y_{it}/Y_{it-1}) \\ &\quad - [\overline{s}_{it}\ log\ \ (L_{it}/L_{it-1}) + (1-\overline{s}_{it})\ log\ \ (K_{it}/K_{it-1})] \end{aligned} \tag{22}$$

Where $\overline{s}_{it}$ is the average cost share of labor between time t and $t-1$.

[24] Van Beveren (2012) also makes reference to problems related to omitted price bias and multi-product firms. However, we will focus on the problems outlined here since they have been under study for much longer and also because they are more relevant in this study.

[25] In the following subsections, the production function will be indexed at the firm-time level instead of being at the firm-industry-region-time level.

One of the main advantages of using index numbers is that they are easy to calculate while keeping the technology fairly flexible. Also, as long as there is some data regarding the inputs, it is easy to modify equation (22) in order to include all the inputs.

The biggest drawback of this approach is that it is very sensitive to the quality of the data and, most importantly, a number of assumptions have to be satisfied: constant returns to scale, competitive input and output markets, and profit maximizing firms.

Next, there are some parametric methods that try to overcome the endogeneity and selection bias. However, we will only explain the non-parametric approaches that have been developed recently. For a more detailed explanation on the parametric approaches see Van Biesebroeck (2003).

C.III.2 Olley and Pakes

Olley and Pakes (1996) (OP henceforth) constitutes a major breakthrough in productivity estimation since they take into account both the endogeneity issue and the selection bias problem. As Ackerberg et al. (2006) (ACF henceforth) point out, the main assumption is that capital is a fixed input that depends on an investment process. Therefore, capital in period t depends on capital in $t-1$ and investment i_{t-1}. This timing helps to solve the endogeneity issue with respect to capital since the decision of capital is taken before the knowledge of the productivity shock.

Therefore, Olley and Pakes (1996) introduce a three-step estimation process where the investment of the firm is a monotonically increasing function of productivity and existing capital.

If the relationship is monotonically increasing, as explained in Arnold (2005), the investment decision is a function of the productivity (ω_{it}) and the capital stock:[26]

$$i_{it} = i_t(\omega_{it}, k_{it})$$

This relation can be inverted and we have a function for productivity that depends on investment and capital:

$$\omega_{it} = h_t(i_{it}, k_{it})$$

Then the estimating equation becomes:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + h_t(i_{it}, k_{it}) + \eta_{it}$$

We can define the function:

[26] For ease of exposition we will only include one variable that represents labor, although in this study we use skilled and unskilled labor as two different inputs.

$$\omega_{it} = \beta_k k_{it} + h_t(i_{it}, k_{it})$$

Thus for the first step, the estimating equation becomes:

$$y_{it} = \beta_0 + \beta_l l_{it} + \phi(i_{it}, k_{it}) + \eta_{it}$$

Since the functional form of $\phi(.)$ is unknown, it can be approximated non-parametrically by a third or fourth degree polynomial. Thus, in the first stage, both $\widehat{\beta_l}$ and $\widehat{\phi}$ can be estimated using regular Ordinary Least Squares (OLS).

In the second step, they introduce a correction for the selection bias (exit decision). Exit is conditional on the realization of productivity, with a given threshold for firms to exit. Both are unknown functions of investment and capital, and they can be estimated through a probit regression for exit. Thus, in the second step, the probability of survival $\widehat{P_{it}}$ is estimated.

Also, since $\widehat{\beta_l}$ has been consistently estimated in the first stage, then it is possible to form a new function $V_{it} = y_{it} - \widehat{\beta_l} l_{it}$ and estimate:

$$V_{it} = \beta_k k_{it} + g(\phi_{it-1} - \beta_k k_{it-1}) + f(\phi_{it-1} - \beta_k k_{it-1})\widehat{P_{it}} + \eta_{it} \tag{23}$$

Where $g(.)$ and $f(.)$ are unknown functions and are therefore estimated using a polynomial approximation as in the first step. However, it is worth noting that in this stage, since there is a given structure for β_k, then this equation has to be estimated using Non Linear Least Squares. Once we have estimates of equation (23) then we obtain consistent estimates of β_l and β_k, enabling the construction of TFP.

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 considerable amount of information is potentially lost.

C.III.3 Levinsohn and Petrin

Since Olley and Pakes (1996) assume that there is a monotonic relation between investment and productivity, then, in order to use that method it is necessary that all the observations with zero investment are dropped from the sample.

As explained above, this could imply a significant loss of observations in the dataset (depending on how many firms do not invest). Since investment is not always positive, Levinsohn and Petrin (2003) (LP henceforth) provide an alternative approach.

The estimation is very much in spirit of Olley and Pakes (1996). However, they use intermediate inputs as a proxy for productivity shocks. As Arnold (2005) points out, typically there are significantly less zero- observations in intermediate inputs than in investment.

C.III.4 Ackerberg, Caves, and Fraser

More recently, Ackerberg et al. (2006) have re-examined the estimation methods for production functions. They shed some light into some issues that might hinder the methodology proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003).

They argue that there may be significant problems with the estimation of production functions if the methods mentioned above are used. The most critical issue are collinearity problems that arise in both methods. If the assumptions of the OP and LP methods hold, then it would be possible to identify β_l in the following equation:[27]

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + h_t(i_{it}, k_{it}) + \eta_{it} \tag{24}$$

Where $h_t(i_{it}, k_{it})$ is the productivity shock (ω_{it}) in the OP methodology. In the LP methodology, it is replaced by $h_t(m_{it}, k_{it})$. ACF argue that there are some collinearity issues between β_l and $h_t(.)$.

Regarding the LP methodology, the issue is whether there is any variation of l_{it} that is independent of the non-parametric term $h_t(.)$. They argue three different scenarios where collinearity would be present. In the first scenario, l_{it} and m_{it} are decided at the same time. In this case, if they are both jointly determined, then it is clear that the choice of labor should also be a function of the productivity shock and the stock of capital. Recall that:

$$m_{it} = m_t(\omega_{it}, k_{it}) \qquad \text{then it should be that:} \qquad l_{it} = l_t(\omega_{it}, k_{it})$$

Therefore, since $\omega_{it} = h_t(m_{it}, k_{it})$, then: $l_{it} = l_t(h_t(m_{it}, k_{it}), k_{it}) = g_t(m_{it}, k_{it})$ where l_{it} is some function of m_{it} and k_{it}. Therefore, l_{it} is collinear with the non-parametric function.

In the second scenario, where l_{it} is decided before m_{it}, then the appropriate function determining the level of intermediate inputs would be:

$$m_{it} = m_t(\omega_{it}, k_{it}, l_{it})$$

This would create a clear correlation with l_{it} in equation (24). The third scenario is when l_{it} is decided after m_{it}. In this scenario, if the productivity shock ω_{it} occurs in

[27] Recall that in the LP methodology, investment is replaced by intermediate inputs m.

between the decision of buying intermediate inputs and hiring labor, then the collinearity disappears. However, this contradicts the assumption that the inversion of the investment function will solve the endogeneity problem.

For the OP methodology, the reasoning is similar. In order to get proper identification of β_l in equation (24) it is necessary that there is some variation of l_{it}. ACF assume that there could be some potential optimization error or measurement error that could lead to variation of l_{it}. However, these, on average, will approach zero.

They propose an approach that takes into account the possibility of collinearity between l_{it} and $h_t(i_{it}, k_{it})$. Consider the production function in logs:[28]

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \eta_{it} \tag{25}$$

Then, following LP, the intermediate input function is:

$$m_{it} = m_t(\omega_{it}, k_{it})$$

Which is assumed to be monotonic and can be inverted, yielding:

$$\omega_{it} = h_t(m_{it}, k_{it})$$

Now, in order to take into account the collinearity issues discussed above, we should have:

$$l_{it} = l_t(\omega_{it}, k_{it}) = l_t(h_t(m_{it}, k_{it}), k_{it}) = g_t(m_{it}, k_{it})$$

If we substitute this into equation (25):

$$y_{it} = \beta_l g_t(m_{it}, k_{it}) + \beta_k k_{it} + h_t(m_{it}, k_{it}) + \eta_{it}$$

Then the estimating equation becomes:

$$y_{it} = \beta_0 + \phi(m_{it}, k_{it}) + \eta_{it} \tag{26}$$

In this equation, $\phi(m_{it}, k_{it})$ combines all the production function terms, including l_{it}. Moreover, β_l is not identifiable from this equation, however; the $\phi(.)$ function can be estimated non-parametrically following the spirit of OP and LP. Therefore, it is possible to obtain values of $\widehat{\phi(.)}$.

Now, similarly as in OP and LP, in a second stage, the estimating equation is similar to the procedure described in the Olley and Pakes section, equation (23):

[28] In this production function, y_{it} is value added, that is, net of materials.

$$
\begin{aligned}
V_{it} = \beta_l l_{it} + \beta_k k_{it} + g(\phi_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1}) \\
+ f(\phi_{it-1} - \beta_k k_{it-1} - \beta_l l_{it-1})\widehat{P_{it}} + \eta_{it}
\end{aligned} \tag{27}
$$

The estimation has to be performed using either non-linear least squares, or an optimization routine.

Table 13: TFP Estimation

	INDUSTRY 24 25 26																
METHOD	15	17	18	19	20	21	22	24	25	26	28	29	31	33	34	35	36
OLS																	
No. of Obs.	10,764	1,656	1,773	883	2,320	1,026	1,716	2,033	2,144	1,816	2,473	1,844	499	205	482	296	1,608
Inskilled	0.49	0.43	0.40	0.45	0.28	0.63	0.45	0.51	0.36	0.51	0.37	0.48	0.38	0.40	0.64	0.47	0.54
Inunskilled	0.41	0.40	0.41	0.41	0.09	0.29	0.33	0.19	0.30	0.23	0.33	0.37	0.34	0.27	0.48	0.33	0.51
Inkstock	0.30	0.27	0.33	0.39	0.46	0.32	0.38	0.38	0.40	0.24	0.35	0.28	0.30	0.40	0.37	0.33	0.21
RTS	1.20	1.10	1.15	1.25	0.83	1.24	1.16	1.07	1.06	0.97	1.06	1.13	1.02	1.08	1.49	1.13	1.26
TORNQVIST INDEX No. of Obs.	8,400	1,295	1,365	681	1,793	818	1,338	1,598	1,672	1,406	1,903	1,414	388	163	366	222	1,211
Inskilled	0.16	0.13	0.15	0.14	0.08	0.07	0.17	0.08	0.08	0.11	0.14	38.00	0.09	0.14	0.13	0.13	0.13
Inunskilled	0.22	0.21	0.19	0.26	0.40	0.11	0.12	0.13	0.34	0.17	0.18	0.14	0.16	0.15	0.22	1.18	0.20
Inkstock	0.62	0.66	0.66	0.60	0.52	0.82	0.71	0.80	0.58	0.72	0.68	0.47	0.75	0.71	0.65	-0.31	0.67
RTS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OP Manually No. of Obs.	4,477	696	578	302	1,088	500	755	1,170	1,064	748	1,044	765	219	95	173	134	543
Inskilled	0.27	0.33	0.21	0.25	0.11	0.17	0.26	0.39	0.23	0.33	0.26	0.36	0.28	0.40	0.44	0.28	0.37
Inunskilled	0.18	0.28	0.24	0.30	0.05	0.05	0.20	0.17	0.19	0.17	0.23	0.30	0.28	0.26	0.36	0.24	0.38
Inkstock	0.12	0.15	0.24	0.07	0.13	0.03	0.28	0.13	0.22	0.09	0.17	0.06	0.06	0.32	0.29	0.11	0.08
RTS	0.56	0.76	0.69	0.62	0.29	0.25	0.74	0.68	0.63	0.59	0.65	0.72	0.62	0.99	1.09	0.62	0.84
Olley and Pakes No. of Obs.	5,604	851	729	388	1,354	618	956	1,468	1,342	961	1,312	969	283	121	218	177	709
Inskilled	0.16	0.20	0.16	0.12	0.10	0.31	0.36	0.15	0.21	0.04	0.23	0.03	0.28	0.29	0.21	0.22	0.26
Inunskilled	0.27	0.33	0.21	0.25	0.10	0.18	0.26	0.38	0.23	0.33	0.26	0.36	0.28	0.40	0.45	0.29	0.38
Inkstock	0.18	0.28	0.24	0.30	0.06	0.06	0.19	0.16	0.19	0.17	0.23	0.29	0.29	0.27	0.35	0.22	0.38
RTS	0.61	0.81	0.61	0.67	0.26	0.55	0.81	0.69	0.63	0.55	0.72	0.68	0.84	0.97	1.01	0.73	1.02
Levinsohn and Petrin No. of Obs.	10,733	1,654	1,771	875	2,317	1,025	1,709	1,953	2,143	1,777	2,469	1,834	499	205	482	296	1,607
Inskilled	0.22	0.34	0.24	0.32	0.14	0.20	0.26	0.46	0.25	0.23	0.27	0.40	0.29	0.38	0.54	0.41	0.38
Inunskilled	0.17	0.31	0.23	0.29	0.07	0.11	0.20	0.17	0.21	0.09	0.24	29.00	0.25	0.18	0.36	0.28	0.37
Inkstock	0.14	0.16	0.17	0.14	0.14	0.07	0.19	0.17	0.23	0.09	0.18	0.11	0.26	0.38	0.26	0.16	0.14
RTS	0.53	0.81	0.64	0.75	0.35	0.38	0.65	0.80	0.69	0.41	0.69	0.80	0.80	0.94	1.16	0.84	0.88
ACF* No. of Obs.	8,400	1,295	1,365	681	1,793	818	1,338	1,598	1,672	1,406	1,903	1,414	388	163	366	222	1,212
Inskilled	0.35	0.48	0.42	0.28	0.40	0.56	0.42	0.54	0.36	0.42	0.36	0.54	0.19	0.47	0.47	0.62	0.46
Inunskilled	0.34	0.64	0.35	0.39	0.29	0.56	0.29	0.21	0.32	0.30	0.34	0.49	0.05	0.42	0.52	0.34	0.56
Inkstock	0.13	0.16	0.22	0.15	0.13	0.06	0.20	0.15	0.21	0.16	0.21	0.10	0.18	0.18	0.16	0.14	0.12
RTS	0.81	1.28	1.00	0.82	0.81	1.18	0.91	0.90	0.90	0.88	0.91	1.14	0.42	1.06	1.14	1.11	1.13

* Ackerberg, Caves, and Fraser

D. Robustness tests

Table 14: No Foreign Presence

Dependent variable log (TFP)	No IPR	Fraser IPR	Dummy IPR
Horizontal Spillovers	0.02	-0.25	-0.21
	(0.96)	(0.46)	(0.24)
Backward Spillovers	4.15**	3.37***	1.41***
	(1.80)	(0.58)	(0.44)
Forward Spillovers	-2.52**	-1.22*	-0.06
	(1.20)	(0.73)	(0.39)
IPR Fraser		-0.58***	
		(0.22)	
IPR Fraser x Horizontal Spillovers		0.01	
		(0.06)	
IPR Fraser x Backward Spillovers		-0.40***	
		(0.05)	
IPR Fraser x Forward Spillovers		0.23**	
		(0.09)	
Dummy IPR			0.11***
			(0.04)
Dummy IPR x Horizontal Spillovers			-0.00
			(0.17)
Dummy IPR x Backward Spillovers			-1.10***
			(0.15)
Dummy IPR x Forward Spillovers			0.70**
			(0.28)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	0.21	0.65	0.65
Observations	2,884	8,932	8,932
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 15: No Foreign Presence.
Balanced Panel

Dependent variable: log (TPF)	No. IPR	Fraser IPR	Dummy IPR
Horizontal Spillovers	0.79	0.31	0.22
	(1.01)	(0.59)	(0.32)
Backward Spillovers	1.20	2.49***	0.77
	(1.96)	(0.76)	(0.54)
Forward Spillovers	-2.47**	-2.12**	-0.77*
	(1.23)	(0.87)	(0.45)
IPR Fraser		-0.39	
		(0.25)	
IPR Fraser x Horizontal Spillovers		-0.02	
		(0.07)	
IPR Fraser x Backward Spillovers		-0.35***	
		(0.07)	
IPR Fraser x Forward Spillovers		0.29**	
		(0.11)	
Dummy IPR			0.13***
			(0.04)
Dummy IPR x Horizontal Spillovers			-0.09
			(0.21)
Dummy IPR x Backward Spillovers			-0.98***
			(0.20)
Dummy IPR x Forward Spillovers			0.84**
			(0.33)
Kleibergen-Paap P-value	0.00	0.00	0.00
Hansen J Statistic P-value	0.31	0.40	0.38
Observations	2,337	7,227	7,227
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 16: No Horizontal Spillovers

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	4.26***	2.66***	1.13***
	(1.30)	(0.55)	(0.41)
Forward Spillovers	-2.84***	-1.33***	-0.30
	(0.79)	(0.48)	(0.29)
IPR Fraser		-0.53**	
		(0.22)	
IPR Fraser x Backward Spillovers		-0.31***	
		(0.07)	
IPR Fraser x Forward Spillovers		021***	
		(0.07)	
Dummy IPR			0.10***
			(0.03)
Dummy IPR x Backward Spillovers			-0.90***
			(0.21)
Dummy IPR x Forward Spillovers			0.61***
			(0.20)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	0.63	0.62	0.63
Observations	2,884	8,932	8,932
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 17: No Horizontal Spillovers.
Balanced Panel

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	2.43	2.12***	0.93**
	(1.90)	(0.67)	(0.42)
Forward Spillovers	-2.26*	-1.56***	-0.51*
	(1.16)	(0.50)	(0.26)
IPR Fraser		-0.56***	
		(0.21)	
IPR Fraser x Backward Spillovers		-0.25***	
		(0.09)	
IPR Fraser x Forward Spillovers		0.22***	
		(0.07)	
Dummy IPR			0.13***
			(0.03)
Dummy IPR x Backward Spillovers			-0.71***
			(0.25)
Dummy IPR x Forward Spillovers			0.63***
			(0.20)
Kleibergen-Paap P-value	0.00	0.00	0.00
Hansen J Statistic P-value	0.12	0.63	0.62
Observations	2,409	7,227	7,227
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 18: No Foreign Presence/Horizontal Spillovers

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	4.26***	3.13***	1.13***
	(1.23)	(0.44)	(0.41)
Forward Spillovers	-2.57***	-1.56***	-0.30
	(0.73)	(0.47)	(0.29)
IPR Fraser		-0.51**	
		(0.20)	
IPR Fraser x Backward Spillovers		-0.39***	
		(0.04)	
IPR Fraser x Forward Spillovers		0.25***	
		(0.06)	
Dummy IPR			0.10***
			(0.03)
Dummy IPR x Backward Spillovers			-0.90***
			(0.21)
Dummy IPR x Forward Spillovers			0.61***
			(0.20)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	0.31	0.78	0.62
Observations	2,884	8,932	8,932
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0. 1

Table 19: No Foreign Presence/Horizontal Spillovers.
Balanced Panel

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	3.65**	2.79***	1.08***
	(1.57)	(0.55)	(0.36)
Forward Spillovers	-2.67***	-1.85***	-0.56**
	(0.95)	(0.46)	(0.25)
IPR Fraser		-0.53***	
		(0.20)	
IPR Fraser x Backward Spillovers		-0.35***	
		(0.06)	
IPR Fraser x Forward Spillovers		0.27***	
		(0.06)	
Dummy IPR			0.14***
			(0.04)
Dummy IPR x Backward Spillovers			-0.98***
			(0.18)
Dummy IPR x Forward Spillovers			0.76***
			(0.17)
Kleibergen-Paap P-value	0.00	0.00	0.00
Hansen J Statistic P-value	0.38	0.63	0.62
Observations	2,409	7,227	7,227
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 20: Horizontal is not used as Instrument

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	4.47**	3.08***	1.32***
	(1.77)	(0.54)	(0.51)
Forward Spillovers	-2.71**	-1.58***	-0.46
	(1.10)	(0.53)	(0.39)
IPR Fraser		-0.55**	
		(0.22)	
1PR Fraser x Backward Spillovers		-0.37***	
		(0.06)	
IPR Fraser x Forward Spillovers		0.24***	
		(0.07)	
Dummy IPR			0.11**
			(0.04)
Dummy IPR x Backward Spillovers			-0.85***
			(0.23)
Dummy IPR x Forward Spillovers			0.56**
			(0.22)
Kleibergen-Paap LM Statistic (under-identification test)	0.00	0.00	0.00
Hansen J Statistic (over-identification test)	0.25	0.48	0.44
Observations	2,884	8,932	8,932
R-squared	0.00	0.00	0.00
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

Table 21: Horizontal is not used as Instrument.
Balanced Panel

Dependent variable: log (TFP)	No IPR	Fraser IPR	Dummy IPR
Backward Spillovers	3.82*	2.21***	0.75
	(2.08)	(0.76)	(0.47)
Froward Spillovers	-2.80**	-1.57***	-0.41
	(1.32)	(0.55)	(0.31)
IPR Fraser		-0.49**	
		(0.22)	
IPR Fraser x Backward Spillovers		-0.31***	
		(0.07)	
IPR Fraser x Forward Spillovers		0.25***	
		(0.06)	
Dummy IPR			0.14***
			(0.04)
Dummy IPR x Backward Spillovers			-0.88***
			(0.21)
Dummy IPR x Forward Spillovers			0.71***
			(0.18)
Kleibergen-Paap P-value	0.00	0.00	0.00
Hansen J Statistic P-value	0.22	0.37	0.37
Observations	2,409	7,227	7,227
Time, Industry and Region Dummies	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0. 1

E. FDI Vs. Licensing

Table 22: Descriptive Statistics (Low-Tech vs. High-Tech Firms)

Variable	Low-Tech Firms (31,300 firms)				High-Tech Firms (2,308 firms)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Capital Stock	1509.42	9322.24	0	680,000	8057.26	48590.63	0	953,000
% Domestic Capital	96.73	16.63	0	100	79.89	38.39	0	100
% Foreign Capital	3.26	16.59	0	100	20.11	38.39	0	100
Value Added	1758.89	8594.42	0	470,000	10496.43	66820.67	0.51	1,720,000
Sale of Production	2934.43	11245.13	0	367,000	16126	105000.00	0	1,770,000
Total Wages	331.84	1793.99	0	275,000	978.91	4879.48	1.87	205,000
Gross Production Value	4078.29	15670.79	2.28	504,000	24622.16	168000.00	6.17	3,480,000
Licenses and Foreign Assistance	4.12	72.84	0	5,578	63	515.47	0	11,864
Income Due to Exports	945.39	6913.39	0	311,000	3118.39	21210.31	0	401,000
Number of Skilled Workers	12.36	43.71	0	1,554	23.08	74.04	0	1,057
Skilled/Unskilled Workers Ratio	0.64	3.39	0	159	0.98	5.03	0	139
Skilled/Total Workers Ratio	0.24	0.3	0	1	0.24	0.29	0	1