Essays on Foreign Direct Investment: Some Missing Pieces



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A ti Felipe, por sacrificar tus propios sueños por ayudarme a alcanzar los míos.

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Abstract

This thesis contains three chapters that examine various channels through which foreign direct investment (FDI) benefits emerging economies, using micro-level data from Chile. The first chapter analyses the effect of foreign ownership on female employment. Using propensity score matching combined with a difference-in-differences approach, and comparing firms operating in the same industry-year, the chapter shows that foreign ownership increases the share of female workers within the firm, and this effect is greater when considering the share of females among skilled workers.

The second chapter analyses the link between training provision to employees, by Chilean firms, and the presence of foreign affiliates in the same industry, as well as in the input-providing (upstream) and input-sourcing (downstream) industries located in the same geographical region. The results suggest that Chilean firms in sectors and regions more likely to receive or supply inputs from/to foreign affiliates spend more on training their workers. That is, there is a vertical linkage between foreign presence and training provision by Chilean firms. This finding is robust to several different econometric specifications, including controlling for unobservable firm heterogeneity, omitted variables and sample selection.

The third chapter examines the role of the distance to technological frontier (DTF) as a mediating factor in productivity spillovers from FDI. The main conclusion of the chapter is that domestic firms need to be not too far away from the technological frontier in order to benefit from FDI.

However, once domestic firms get too close to the frontier, the potential for positive FDI spillovers decreases. That is, the chapter provides evidence of an inverse U-shaped relationship between productivity spillovers from FDI and the DTF for Chilean manufacturing firms over the period 1995-2006.

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Chapter 1

Foreign Acquisitions and Female Employment in Manufacturing Firms: An Empirical Analysis for Chile

1.1 Introduction

Are foreign-owned firms more female-friendly than domestic firms? Although a large body of empirical literature examines the impact of multinationals on several aspects of firms (skill composition, wages, productivity, among others), gender issues are generally ignored. We shed light on this neglected topic by empirically evaluating whether foreign-owned firms hire proportionally more female workers than their domestic counterparts, using plant-level data from Chilean manufacturing[1]. Namely, we investigate whether, upon being acquired, foreign plants hire more female workers than they would have done had they remained domestic.

A potential problem when estimating the causal effect of foreign acquisitions on the share of female employees is the possible endogeneity of firms being acquired. Foreign-acquired firms might exhibit characteristics that systematically differ from those of non-acquired firms, which implies that the acquired firms are not randomly selected. As a consequence, estimates that do not consider this non-randomness

[1] Although a plant is not necessarily a firm, Pavcnik (2002) points out that more than 90 per cent of Chilean manufacturing firms are single-plant. For this reason, hereafter, we will use the words plant and firm interchangeably.

will be biased (because of selection bias). For this reason, we use propensity score matching combined with a difference-in-differences technique, as suggested by, for example, Blundell & Costa Dias (2000). The aim of this procedure is to find a group of non-acquired firms with similar characteristics to the group of acquired firms and then compare the share of female employees within acquired and non-acquired firms. Additionally, the matched control firms are assigned only from the same year and the same sector as the foreign acquired firm.

The underlying question of this study is why foreign firms should be expected to hire more women than domestic firms. The basic explanation is related to Becker's (1957) seminal theory on taste-based discrimination, which predicts that, under some conditions, competitive pressures will work to reduce discriminatory or other inefficient management practices, because discrimination comes at a cost to the firm owner. Thus, as explained by Heyman *et al.* (2013), if competition is strong, discriminating firms will be competed out of the market or may change their behaviour as competition increases the costs incurred by discriminating firms. Since foreign firms usually operate in more competitive markets they cannot afford taste-based discrimination. Therefore, one can expect that the share of female employees to increase after a foreign acquisition has taken place, and this effect should be larger when market competition was weak before the acquisition. We present evidence supporting this explanation.

An alternative explanation for foreign direct investment's (FDI's) potential to increase female employment is given by Lawler & Bae (1998). According to them, cultural differences in terms of gender equality between the multinationals' home countries and the host countries may explain why foreign firms are more female-friendly than domestic plants. Culture is defined as *"the beliefs, attitudes, norms, role expectations, and values widely shared by the members of a particular group"*, which *"can influence behaviour in a variety of ways"*, including a firm's manage-

ment practices relating to the role of women in the labour market (Lawler & Bae, 1998: 129). Therefore, when the multinational's home country promotes employment, training and promotions for female workers, the parent firm may transfer its gender policies to its subsidiaries in the host country[2].

Chile is a suitable choice for studying the effects of FDI on female employment for two reasons. First, because the country has received significant inflows of FDI since the early 1970s. Second, because it exhibits a large amount of discrimination against women in the labour market. Incoming FDI has maintained an upward trend since 1973, leading to Chile gaining widespread international recognition for its success in attracting FDI. Since 1990, Chile has been one of the emerging market economies with the greatest FDI inflows relative to GDP (Table A.1). Indeed, as share of GDP, the net FDI inflows into Chile are greater than those into all the BRIC economies (Brazil, Russia, India and China) and Mexico.

Discrimination against women in the labour market is clearly reflected in the size of the wage gap between men and women —controlling for educational levels, experience, economic activity, location, work intensity and occupation— as well as in the attitude towards women doing paid work. According to data from the International Labour Organization (ILO, 2015), unexplained gender wage gap in Chile reached 22.2 per cent in 2011, and the gap widens for the top-earning women. In addition, the attitudes towards women being remunerated for work are still very negative in the country. According to the United Nations Development Programme (UNDP, 2010), survey data in Chile show that, in 2002, only 23 per cent of all survey respondents approved of women working full-time, regardless of the family situation (i.e. whether or not they have children and irrespective of the children's ages), 37 per cent took

[2]This hypothesis has been tested by Tang & Zhang (2017) for Chinese manufacturing firms over the period 2004-2007. They find that foreign firms from countries with lower gender inequality tend to hire proportionately more women and are more likely to appoint female managers. Kodama *et al.* (2018) also present evidence supporting this hypothesis for Japan. Unfortunately, our data set does not allow us to test this hypothesis, since we do not have data about the origin country of foreign affiliates.

an intermediate view, with their approval depending on the age of the woman's children, and the remaining 38 per cent disapproved of women doing paid work under any (family) circumstances. A significant improvement was observed in 2009 when 38 per cent of all survey respondents approved of women doing paid work, 39 per cent expressed an intermediate view, and 23 per cent disapproved.

When we compare Chile with other countries from the region, we observe that its performance in terms of gender equality is still insufficient. This fact is evident when we analyse the Gender Empowerment Measure (GEM) (Table A.2) which is constructed by the United Nations Development Programme (UNDP) to measure female participation in economic and political decisions. The higher the GEM, the more empowered are women. The index is constructed for 109 countries worldwide, among which Chile was ranked 75th in 2009, and 19th among 23 countries from Latin America and the Caribbean. When we compare Chile with other countries from the region, we observe that there are considerable differences in terms of women's access to power. For instance, women's share of seats in parliament is 13.9 per cent, in contrast to Argentina with 37.7 per cent and Mexico with 36 per cent.

We use plant-level data from the National Annual Manufacturing Survey (Encuesta Nacional Industrial Anual, ENIA) collected by the Chilean Institute of Statistics (Instituto Nacional de Estadísticas, INE), over the period 1995-2006. The survey covers the universe of Chilean plants in manufacturing with at least 10 employees. There are more than 5,000 plants per year in the sample. The ENIA contains information on different aspects of firm structure, such as ownership, sector, production inputs and outputs, exports, among others. More importantly for our purposes, it includes information about the total number of (full-time) employees, separated by occupation and gender.

We find a positive effect of foreign ownership on increasing the proportion of female workers. Our results show that one year after acquisition the share of female

workers is 1.64 percentage points higher in foreign-acquired firms than in non-acquired firms, and this figure increases to 3.55 percentage points two years after acquisition. When we separate female workers among skilled and unskilled, we observe that the positive effect of foreign acquisition is only present for skilled women. One year after acquisition, the share of skilled women is 4.60 percentage points higher in foreign-acquired firms than in non-acquired ones, and to 6.63 percentage points two years after acquisition. In addition, we present evidence that foreign acquisition increases the share of skilled women only when the acquired firm was not an exporter before its acquisition, supporting Becker's (1957) theory on taste-based discrimination, but only when considering skilled female workers.

As a robustness check of our results, we evaluate the impact on female employment of domestic takeovers, that is, a change in ownership from foreign to local investors. We find that when ownership reverts to domestic hands, the change in the share of women among workers is not statistically different from zero for either skilled or unskilled women or women overall. This result suggests that domestic owners do not affect the gender structure of the labour force when they take back control of the firm, confirming that foreign ownership does have a positive effect in increasing the share of female employees.

The contribution of our study is twofold. First, our analysis relies on foreign acquisitions, which makes our identification strategy stronger in comparison to previous works. Second, we are also able to distinguish between skilled and unskilled workers, which allow us to confirm the existence of differences in the hiring practices by gender according to the skill level of workers.

The remainder of this chapter is organized as follows. Section 1.2 reviews the related literature. Section 1.3 outlines our empirical strategy. Section 1.4 presents our estimates of the propensity score. Section 1.5 discusses the results from the difference-in-differences analysis on the matched sample. Section 1.6 presents the robustness

checks. Section 1.7 evaluates Becker's (1957) theory on taste-based discrimination using information about exporting firms. Section 1.8 concludes.

1.2 Related Literature

This chapter is related to two strands of the economic literature. The first strand examines the impact of trade liberalization and FDI on gender labour outcomes, particularly wage gap and female employment share. The second strand of the literature related to this chapter documents the relation between market competition and taste-based discrimination.

The existing literature analysing the impact of trade liberalization and FDI on female labour outcomes is still limited and their conclusions are mixed[3]. Juhn *et al.* (2014) use data from Mexico to conclude that trade liberalization improves women's labour outcomes in the blue-collar tasks, but does not affect women in the the white-collar tasks. Tejani & Milberg (2016) use a sample of 60 high-income developed countries and middle-income developing countries over the period 1985 to 2007 to study the effects of trade liberalization on the female employment share in manufacturing. They find that the relative employment of women increased in developing countries but decreased in the high-income ones.

Meanwhile, other authors have found that international trade increases gender wage gaps. That is the case of Bøler *et al.* (2018) for Norway. They argue that exporter firms require greater commitment from their employees. If women are less flexible (or perceived as such) exporters will exhibit a higher gender wage gap than non-exporters. Using matched employer-employee data from the Norwegian manufacturing sector over 1996-2010, they find that starting to export increases the gender wage gap in about 3 percentage points for highly educated women. Other authors

[3] An extensive literature survey about the effects of trade liberalization on female discrimination can be found in Aguayo-Tellez (2011).

have also reported an increase in gender wage gap due to trade liberalization (e.g. Berik *et al.* (2004) for Taiwan and South Korea and Menon & van der Meulen Rodgers (2009) for India).

More closely related to our chapter are studies on the impact of FDI on the female labour outcomes. Oostendorp (2009) uses an industry-level panel of developed and developing countries using an IV approach, and finds that the gender wage gap tends to decrease with increasing FDI inflows in richer countries, but not in developing economies. Heyman *et al.* (2013) evaluate the impact of foreign takeovers on the gender wage gap and on the gender composition of the labour force in Sweden, using linked employer-employee data. They find no change in female relative wages following a takeover, and only a small increase in the share of female workers when market competition is very weak (close to a monopoly) in the sector where the takeover takes place.

Chen *et al.* (2013) find that foreign firms in China, particularly those with high export orientation, have a higher propensity to hire women, though the gender wage gap tends to be significantly larger when compared to domestic firms. Siegel *et al.* (2018) use firm-level data from South Korea to conclude that multinationals are significantly more likely to have female managers and to implement policies that are beneficial to female employees, such as maternity leave, childcare facilities, and financial support for childcare. Using anecdotal case studies for female Japanese managers, Bozkurt (2012) concludes that multinationals offer better opportunities for high-skilled Japanese women to progress in managerial careers than do domestic firms. Similar conclusions are found by Kodama *et al.* (2018) who examine the effect of foreign ownership on gender-related employment outcomes and work practices in Japan. Foreign firms are found to have a greater share of females among workers, managers, directors, and board members, and also to offer more facilities in terms of flexibility, child-care subsidies and telecommuting. The authors conclude that the

difference in gender-related outcomes is driven mostly by older foreign affiliates where the foreign parent owns a larger share of the firm. These patterns are interpreted by the authors as a signal that transplanting corporate culture from abroad takes time and is facilitated by having greater control over operations. Finally, Tang & Zhang (2017) find that foreign firms from countries with lower gender inequality tend to hire proportionately more women and are more likely to appoint female managers, using data for Chinese manufacturing firms over the period 2004-2007.

The second strand of the literature related to this chapter documents the relation between market competition and taste-based discrimination. Previous research on the relation between market competition and labour market discrimination against women finds supporting evidence for competition reducing gender discrimination. For instance, using industry-level data from the US manufacturing sector, Black & Brainerd (2004) compare the change in the gender wage gap between 1976 and 1993 in concentrated versus competitive manufacturing industries, using a difference-in-difference approach. The authors find that the gender wage gap narrowed in concentrated industries that experienced a reduction in tariffs, but not in competitive industries, and they interpret this result as supporting Becker's taste-based discrimination theory. Meng (2004) finds that Australian firms that are more likely to have narrower gender earnings gaps are those subject to strong market competition. Similar conclusions are found by Hellerstein *et al.* (2002) for the US and by Zweimüller *et al.* (2008) who use a cross-country sample.

Our study differs from the previous literature in two respects. First, we advance in the empirical methodology by using a difference-in-differences approach combined with propensity score kernel matching to deal with potential endogeneity[4]. Second, we also evaluate the effects of foreign ownership on both skilled and unskilled female employment share. Data provided by the Chilean National Institute of Statistics

[4]The recently published work of Kodama *et al.* (2018) also apply this methodology, using nearest-neighbour matching rather than kernel matching.

(INE, by its Spanish acronym) suggest that the higher the level of qualifications of a Chilean woman, the greater is the discrimination she suffers in the labour market, measured by the gender wage gap (INE, 2016). The higher gap is observed for women with postgraduate studies, who had a wage gap of 39.6 per cent. On the contrary, females with only primary education have the lower wage gap (15.5 per cent). For this reason, we consider that the effect of foreign ownership on the gender composition of labour force may differ according to the skill level of the women concerned.

1.3 Empirical Methodology

The aim of our empirical analysis is to assess the effect of foreign ownership on the share of female workers relative to total employment[5]. In order to achieve this goal we proceed as follows. Firstly, we focus on firms that have changed their ownership status from domestic to foreign, that is, domestic firms that have been acquired by foreign investors[6]. We define a foreign acquisition as a situation in which foreign participation has increased to more than 10 per cent[7]. Our core estimates are restricted to the set of manufacturing firms that were switched from domestic to foreign ownership and remained in the data sufficiently long to be observed one year before acquisition, in the acquisition year and two consecutive years after the acquisition.

Once we have identified the foreign-acquired firms, we can use a difference-in-differences approach to compare the average share of female workers observed in the foreign-acquired firms (the treatment group) with the share of female workers

[5]Note that, our database does not have information about wages separated by the worker's gender, thus we are unable to estimate gender wage gaps.

[6]As a robustness check we also consider domestic acquisitions, that is, firms whose ownership has changed from foreign to domestic. Section 1.6.2 shows that when ownership reverts to domestic hands, the share of female workers within the firm is unchanged.

[7]Empirical literature usually follows the OECD Benchmark Definition of FDI, which establishes that a firm can be considered as foreign if at least 10 per cent of its capital is owned by foreign investors (OECD, 1999). See, for example, Javorcik (2004).

in the firms that remain under domestic control (the control group). However, this comparison may be biased due to non-random sample selection.

Empirical evidence suggests that acquisition is not an exogenous decision and, on the contrary, foreign investors "cherry pick" the best domestic firms as their targets (Arnold & Javorcik, 2009; Almeida, 2007). In order to address the selection issue, we combine the difference-in-differences approach with propensity score matching. As stated by Arnold & Javorcik (2009), the advantage of this approach is that *"we eliminate the influence of all observable and unobservable non-random elements of the acquisition decision that are constant or strongly persistent over time"*. This technique has been used by previous researchers to analyse the effects of foreign acquisitions on other variables. For instance, Girma & Görg (2007) evaluate the effect of foreign acquisitions on wages in the UK, and Arnold & Javorcik (2009) examine plant performance outcomes for Indonesian firms.

The aim of the propensity score matching is to construct the unobserved counterfactual of how the acquired firm would have performed in the absence of ownership change. This is done by matching each foreign-acquired firm with a group of comparable non-acquired firms with similar pre-acquisition characteristics, such as productivity, size, exporter status, etc. Since this procedure would imply to compare acquired and non-acquired firms across a large number of variables, Rosenbaum & Rubin (1983) suggest the use of the conditional probability of receiving treatment given some pre-treatment variables (named propensity score) to perform the matching. In our context, the propensity score is the predicted probability of a firm receiving FDI. This procedure reduces the dimensionality of the matching process to a single index, namely the propensity score.

In Section 1.4 we estimate the probability of a firm being acquired by foreign investors using a probit model. As explanatory variables in the probit model we include observable firm characteristics such as total factor productivity (TFP), firm

size, share of imported inputs, exporter status, and share of female workers within the firm, among others.

Having obtained the propensity score, we employ kernel matching (KM), in which multiple control observations (non-acquired firms) within the common support[8] are used and the weight given to each is determined by the distance in the propensity score from the acquired firm. Note that the matching is performed in the pre-acquisition year. Different from one to one matching estimators (such as nearest neighbour), KM uses weighted averages of all firms in the control group to construct the counterfactual outcome. Higher weight is given to controls whose propensity score is closer to that of the acquired firm, while lower weight is given to more distant controls. Thus, one major advantage of this approach is the lower variance which is achieved because more information is used. A drawback of KM is that possibly observations are used that are bad matches. Hence, the proper imposition of the common support condition is of major importance for KM (Caliendo & Kopeinig, 2008).

To identify the treatment effect, the so called balancing property of the propensity score must be fulfilled. This implies that observations with the same propensity score must have the same distribution of characteristics, independently of treatment status. In other words, for a given propensity score, exposure to treatment is random and therefore acquired and non-acquired firms should be, on average, observationally identical (Becker & Ichino, 2002). Our estimated propensity score satisfies the balancing property[9]. Moreover, following Arnold & Javorcik (2009), we restrict the matched control observations to come from the same sector and year as the acquired firm[10]. This, in terms of the authors, *"eliminates the possibility that differences in productivity or other aspects of plant operations observed across sector-year combinations exert*

[8]The common support is bound by the lowest propensity score of a treatment observation and the highest propensity score of a control observation.

[9]Appendix B presents our balancing tests.

[10]Our matching procedure is implemented in Stata 12 using the procedure described in Arnold & Javorcik (2009), which guarantees that treated and control firms come from the same year and sector. We thank the authors for kindly sharing their code.

influence on our estimated effects" (Arnold & Javorcik 2009: 44).

1.3.1 Data description

The data used in this chapter come from the Annual National Manufacturing Survey (ENIA, by its Spanish acronym) carried out by the INE. This survey is a census which includes all Chilean manufacturing plants with at least ten workers and three months of operation in the year of reference. It includes approximately 5,000 plants per year. The data constitute an unbalanced panel covering the period 1995-2006. This survey is well known in the literature and has been used by several authors[11].

This survey captures detailed information on different aspects of establishment's characteristics, such as ownership structure, the five-digit ISIC sector, size, gross nominal output, value-added, investment, intermediate inputs, capital stock and employment. It also reports the total number of (full-time) employees[12], separated by occupation and gender. We group workers into two categories: skilled and unskilled. Skilled workers include the following occupations: owners, managers, administrative personnel and specialized workers. Unskilled workers comprise non-qualified workers directly or indirectly involved in the production process, sellers, personal service workers, and home workers.

The data were subjected to the following initial cleaning process. We excluded the tobacco (ISIC 314), petroleum refining (ISIC 353), wholesale trade (ISIC 610) and business services (ISIC 832) industries from the sample because of a lack of representation (less than five firms operating in the sector). Furthermore, we only kept those firms for which information on the key variables was available[13].

[11] See for instance Pavcnik (2002) and Levinsohn & Petrin (2003).

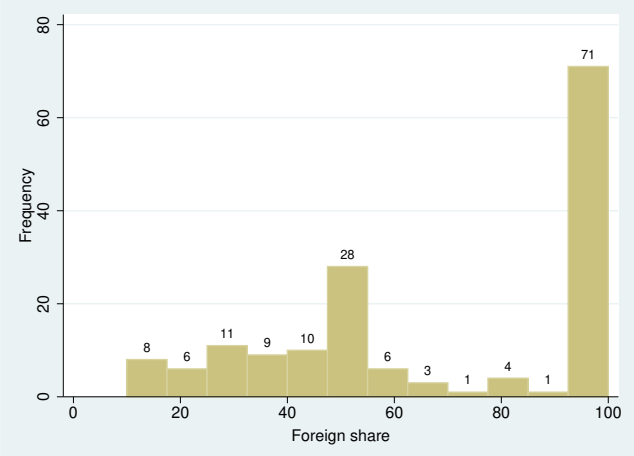
[12] Unfortunately, we do not have data about part-time workers, which could provide important information for our analysis since part-time jobs may be an important employment alternative for women.

[13] The share of firm-year observations that were dropped represents 29 per cent of the original sample. Nevertheless, the representation of dropped observations in total output is only 2 per cent.

1.3.2 Foreign-acquired firms

In total, 158 firms in our sample were foreign-acquired, of which 71 firms (45 per cent) were fully acquired by foreigners, i.e. foreigners acquired 100 per cent of firm's total assets. Indeed, 57 per cent (90 out of 158) of the acquisitions resulted in foreign control of the firm (i.e. foreigners owning more than 51 per cent of the property) (Figure 1.1).

Figure 1.1: Foreign Property Share in Acquired Firms (Number of Firms)



Regarding the sectors in which acquisitions took place, in Table 1.1 we observe that the industries in which most of the acquisitions were concentrated were the manufacture of food and beverages (37 per cent of total acquisitions) and the manufacture of chemicals, coal, rubber and plastic products (22 per cent of total acquisitions). Other industries in which acquisitions also took place were: the manufacture of wood and wood products (11 per cent of total acquisitions), textile, wearing apparel and leather industries (9 per cent of total acquisitions), and the manufacture of fabricated metal products, machinery and equipment (9 per cent of total acquisitions).

Table 1.1: Foreign-acquired Firms by Industry

	Number of acquisitions	Percentage
Manufacture of Food and Beverages	58	37%
Textile, Wearing Apparel and Leather Industries	15	9%
Manufacture of Wood and Wood Products	18	11%
Manufacture of Paper and Paper Products	7	4%
Manufacture of Chemicals, Coal, Rubber and Plastic Products	35	22%
Manufacture of Non-Metallic Mineral Products	5	3%
Basic Metal Industries	4	3%
Manufacture of Fabricated Metal Products	15	9%
Other Manufacturing Industries	1	1%
Total	158	100%

1.4 Estimation of the Propensity Score

This section describes the estimation of the propensity score, which in our case is the probability of a firm being acquired by foreign investors. As a first step in our analysis, we need to obtain the probability of a local firm being acquired by foreign investors (our propensity score). We do so by estimating a probit model. The selection of explanatory variables is based on previous studies, such as Arnold & Javorcik (2009) and Alfaro & Chen (2012). In particular, we incorporate variables related to the production structure of the firm, such as (ln) TFP[14], size (measured by the (ln) total number of workers), capital per worker (ln), the share of female among total workers as well as among total skilled workers. We also include variables capturing the openness of the firm to foreign markets (exporter dummy and share of imported

[14] We estimate TFP following the generalized method of moments (GMM) suggested by Wooldridge (2009). This methodology controls for both endogeneity and selection biases. It also corrects the collinearity problem outlined by Ackerberg *et al.* (2015) of two-steps estimation techniques suggested in Olley & Pakes (1996) and Levinsohn & Petrin (2003). Further details about this methodology are given in Chapter 3.

inputs). Additionally, we consider that the presence of other foreign firms in the sector[15] may motivate foreign investors to acquire a local establishment. The complete list of explanatory variables with their means and standard deviations is included in Table 1.2.

Table 1.2: Summary Statistics

	Mean	Std.dev	No. of obs.
ln(TFP)	8.892	1.395	56,598
ln(Employment)	3.466	1.114	62,473
Female labour share (%)	23.71	22.90	62,473
Skilled female labour share (%)	28.95	25.25	62,702
Share of imported inputs (%)	7.355	19.53	62,224
Exporter dummy	0.202	0.402	62,702
ln(Capital per worker)	8.333	1.691	57,259
Foreign presence in the sector	0.145	0.159	62,702

The results from the probit model are presented in Table 1.3. As expected, more productive, larger and more capital-intensive plants are more attractive to foreign investors. Plants with larger share of female workers are also more attractive for foreign investors (although the variable is significant only at the 10 per cent level). Additionally, we find that a firm's openness to international markets (measured by the share of imported inputs and a dummy for exporter status) as well as the presence of other foreign firms in the sector are important determinants of the acquisition decision. On the other hand, the share of skilled female workers within the firm seems not to be important in the identification of an acquisition target. Finally, we include a time trend, which is statistically significant.

Based on the predicted probability of being acquired by foreign investors (the propensity score), we perform our matching procedure. The balancing property of

[15]Following Javorcik (2004), we define the extent of the foreign presence in the four-digit sector j at time t as the foreign equity participation, averaged over all firms in the sector, weighted by each firm's share in sectoral output. That is, $Foreign_presence_{jt} = \frac{\sum_{i:\, i\epsilon j} foreign_share_{it} \times y_{it}}{\sum_{i:\, i\epsilon j} y_{it}}$

the propensity score is tested and satisfied[16]. In other words, there is not a statistically significant difference in the means of the variables considered between the acquired (treated) firms and the matched controls (non-acquired firms). Therefore, we can be confident that our propensity score is appropriate to perform the matching.

Table 1.3: Probit Results. Predicting Foreign Acquisitions

$\ln(\text{TFP})_{t-1}$	0.0539***
	(0.0202)
$\ln(\text{Employment})_{t-1}$	0.155***
	(0.00169)
Female labour share $_{t-1}$	0.00288*
	(0.00169)
Skilled female labour share $_{t-1}$	-0.00413**
	(0.00185)
Imported inputs share $_{t-1}$	0.337***
	(0.108)
Exporter dummy $_{t-1}$	0.217***
	(0.0693)
ln(Capital per worker) $_{t-1}$	0.102***
	(0.0242)
Foreign presence in the sector $_{t-1}$	0.455***
	(0.161)
Time trend	-0.0744***
	(0.0103)
No. of obs.	44,607
Pseudo R^2	0.149
Chi^2	321.6

Standard errors in parentheses.

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

The model includes an intercept that is not reported.

[16]The main idea behind balancing tests is to check if at each value of the propensity score, the pre-acquisition variables used to estimate the propensity score (X_{t-1}) have the same distribution for the treatment and comparison groups. Balancing tests proposed on the literature mainly evaluate equality of means and variance. The balancing tests are presented in Appendix B below.

1.5 Results from the Difference-in-Differences Propensity Score Matching

We now present the difference-in-differences matching estimates. These estimates give the effects of foreign ownership on the share of female employees (total, skilled and unskilled) in a firm's workforce. Table 1.4 reports the average treatment effect on the treated group of firms (ATT). We present bootstrapped standard errors.

Looking at the share of women among all workers (first column of Table 1.4) we observe a positive and significant effect —at 10 and 5 per cent significance level, respectively— for the first and second years after acquisition. One year after acquisition, the total share of female workers within foreign acquired firms rises by around 1.64 percentage points, and two years after acquisition this figure increases to 3.55 percentage points. These magnitudes are economically meaningful. Considering that the average share of women among total workers in our data set is 23.63 per cent, the estimates imply that foreign acquisitions raise the participation of females by nearly 7 per cent one year after acquisition and by 15 per cent two years after acquisition with respect to the average.

When considering the ratio of skilled female employees to total skilled workers (second column of Table 1.4), we can observe that, in the year of acquisition, the ATT is not statistically different from zero. However, in the following two years the effect of foreign acquisition is positive and significant —at the 5 per cent level—. One year after acquisition the ATT is equal to 4.60 percentage points. That is, after considering the initial difference between the two groups, the share of skilled female workers in the foreign-acquired plants is 4.60 percentage points higher than it is in non-acquired plants. In the following year (two years after acquisition) the figure increases to 6.63 percentage points. In terms of magnitude the observed effect is larger for the share of skilled women than when including all females. Once again, the estimates are economically meaningful. The average share of skilled women workers

in our sample is 29 per cent. Therefore, foreign acquisition increases the share of women among skilled workers by 15.9 per cent one year after acquisition and 22.9 per cent two years after with respect to the average share.

Next, we evaluate the effect of foreign ownership on the share of unskilled women —the ratio of unskilled female workers to total unskilled workers— (Table 1.4, Column 3). In this case, we observe that the effect of foreign ownership is not statistically different from zero for any of the years under consideration.

These results suggest that foreign ownership increases the share of female workers within the firm. However, the effect seems to be only important (and significant) among skilled women. Our results are consistent with two possible explanations: (i) foreign firms being exposed to more competition and hence being less able to discriminate; (ii) foreign firms' attitudes towards women reflecting the culture of their home country. Unfortunately, we do not have information to test (ii), but the evidence on exporters (see Section 1.7 below) points towards (i).

Table 1.4: Matching Results for the Share of Female Workers

	(1)	(2)	(3)
	All women (%)	Skilled women (%)	Unskilled women (%)
	ATT	ATT	ATT
Acquisition year	-0.7800	0.9933	-1.3709
	(0.6427)	(1.158)	(1.347)
One year later	1.6395*	4.6016***	-0.8481
	(0.871)	(1.433)	(1.424)
Two years later	3.5555***	6.6330***	0.6580
	(0.885)	(1.018)	(1.449)
No. of acquisitions	158	158	158

Bootstrapped standard errors in parentheses (300 repetitions).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

1.5.1 What about male workers?

Our baseline results show an increase in the share of female workers within foreign-acquired firms. The effect is stronger for skilled females. However, these findings may be due to the hiring of more female workers or because of the firing of male workers. To evaluate this possibility we perform our matching process using the (ln) total number of female and male workers as our variables of interest.

Results are presented in Table 1.5. As we can observe, there is a positive and statistically significant effect for the total number of female workers. One year after acquisition, the total number of female workers increases by around 0.19 per cent, and by 0.27 per cent two years later. The skilled female workers increases by 0.17 per cent one year after acquisition and by 0.22 per cent two years later. In the case of unskilled female workers we only find a positive and significant effect after two years of foreign control, equal to 0.19 per cent. We do not find a statistically significant effect for male workers, neither for skilled or unskilled.

In sum, the increase in the share of female workers within foreign-acquired firms reported in our baseline results may be explained by a higher hiring of female workers. Foreign firms seem not to alter the number of male workers after taking control of domestic firms.

1.6 Robustness Checks

In order to evaluate the robustness of our above results, we conduct three checks. First, we strengthen our definition of foreign acquisition. Second, we evaluate the effect of domestic acquisitions on the share of female workers. Third, we apply alternative empirical strategies.

Table 1.5: Matching Results for the Total Female and Male Workers (ln)

	(1)		(2)		(3)	
	All		Skilled		Unskilled	
	Women	Male	Women	Male	Women	Male
Acquisition year	0.0246	0.0240	0.0394	-0.0106	0.0022	0.0417
	(0.0698)	(0.0311)	(0.0585)	(0.0551)	(0.0868)	(0.0822)
One year later	0.1929***	0.0594	0.1780***	0.0123	0.1169	0.0977
	(0.0532)	(0.0444)	(0.0635)	(0.0425)	(0.0936)	(0.0704)
Two years later	0.2702***	0.0385	0.2217***	-0.0303	0.1891**	0.1216
	(0.0857)	(0.0626)	(0.0493)	(0.0592)	(0.0919)	(0.0753)
No. of acquisitions	158	158	158	158	158	158

Bootstrapped standard errors in parentheses (300 repetitions).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

1.6.1 An alternative definition of foreign acquisition

As a first way of checking the robustness of our results, we change our definition of foreign acquisition. We now define a foreign acquisition as a situation in which foreign participation in a firm's equity reaches 50 per cent, and perform a new matching process. Since this definition is tighter, the number of foreign-acquired firms decreases to 131.

The matching results are presented in Table 1.6. When we consider the total share of all female workers in the firm (Table 1.6, Column 1), we observe a positive and significant effect —at the one per cent level— for the second and third years under foreign control. In both years, the magnitude of the effect is somewhat greater than when we use the benchmark definition of foreign acquisition: 1.80 vs 1.64 percentage points one year after acquisition, and 3.88 vs 3.55 percentage points for the following year. In the case of skilled female workers (Table 1.6, Column 2), we observe that, for the acquisition year, the effect of foreign ownership is not statistically different from zero. One and two years after foreign acquisition, the effect of foreign ownership is significant at the one per cent level, and the magnitude of the effect is very similar

than our previous estimates. Finally, the effect of foreign ownership on the share of unskilled female employees is not statistically different from zero for the year of acquisition and the following years (Table 1.6, Column 3).

In sum, our main results are valid even when we use a tighter definition of foreign acquisition. Namely, foreign ownership increases the total share of women working within the acquired firms for the two first years after acquisition. The magnitude of the effect depends on the definition of foreign acquisition applied. Similarly to when we used the benchmark definition of foreign acquisition, the effect of foreign ownership is higher when we consider only skilled women. For unskilled women, the effect of foreign ownership is not statistically different from zero regardless of whether we use our benchmark definition or the tighter definition of foreign acquisition.

Table 1.6: Matching Results under an Alternative Definition of Foreign Acquisition

	(1)	(2)	(3)
	All women (%)	Skilled women (%)	Unskilled women (%)
	ATT	ATT	ATT
Acquisition year	-0.3261	1.2154	-1.0352
	(0.7066)	(1.1937)	(1.8628)
One year later	1.7954 ***	3.5735***	-0.6659
	(0.7147)	(1.2769)	(1.3928)
Two years later	3.8893 ***	5.9543***	1.0765
	(1.01518)	(1.5730)	(1.3099)
No. of acquisitions	131	131	131

Bootstrapped standard errors in parentheses (300 repetitions).
*,**, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

1.6.2 Just a matter of acquisition?

We are also interested in determining whether the observed effects on female employment are due to foreign ownership or just because of the change in ownership. To do so, we follow exactly the same procedure as before (see Section 1.3 for details),

but this time we consider domestic acquisitions, that is, a change in ownership from foreign to local investors. We define a domestic acquisition as a situation in which a domestic investor becomes the owner of more than 90 per cent of the firm's property. Foreign firms are now our control group. In this case we have 175 domestic takeovers.

As a first step we estimate a probit model to obtain the probability of a foreign firm being acquired by domestic investors (our propensity score). We include the same explanatory variables in the probit model as in the case of foreign acquisitions, except for the presence of foreign firms in the sector. Using our estimated propensity score, we performed the kernel matching, and then estimate the impact of domestic takeovers over the female employment share.

As shown in Table 1.7 when ownership reverts to domestic hands, the change in the share of female workers within the firm is not statistically different from zero for either skilled or unskilled women or women overall. This result suggests that domestic owners do not affect the gender structure of the labour force when they take back control of the firm, which confirms our finding that foreign ownership does have a positive effect in increasing the share of female employees. Therefore it is not just a change in ownership that explains this positive impact.

1.6.3 Alternative empirical strategies: Fixed effects and propensity score weighting

As alternatives to our difference-in-differences matching estimates, we apply two empirical strategies to estimate the effect of foreign ownership on the share of a firm's employees (both skilled and unskilled) who are female. First, we use the panel structure of our database and estimate a fixed effects regression. We estimate the following regression:

$$Female_share_{it} = \alpha + \gamma acquired_{it} + \sum_j \beta^j X^j_{i,t-1} + d_t + \eta_i + \varepsilon_{it} \qquad (1.1)$$

Table 1.7: Matching Results for Domestic Acquisitions

	(1)	(2)	(3)
	All women (%)	Skilled women (%)	Unskilled women (%)
	ATT	ATT	ATT
Acquisition year	0.7407	-0.1487	3.3232
	(0.8190)	(1.8796)	(2.023901)
One year later	-0.7691	-1.9678	0.6039
	(0.5824)	(1.1705)	(1.4241)
Two years later	-1.2583	-1.7787	-0.4632
	(1.7258)	(1.3686)	(1.2749)
No. of matches	175	175	175

Boostrapped standard errors in parentheses (300 repetitions).

*,**, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

where $Female_share_{it}$ represents the share of skilled (unskilled or all) women employed by firm i in time period t, and *acquired* is an indicator variable taking the value of one in the period in which a change in ownership from domestic to foreign investors is recorded and in subsequent periods. $X^{j}_{i,t-1}$ is a set of j (lagged) firm-level control variables, such as the (ln) firm size, (ln) capital intensity, the share of women among skilled workers, and (ln) TFP. Finally, d_t and η_i are firm and time period fixed effects and ε_{it} is the error term.

Including a firm fixed effect helps us to control for selection based on time-invariant firm characteristics, while the inclusion of the vector $X^{j}_{i,t-1}$ controls for selection on time-varying observables[17]. This strategy ensures that the estimates of the parameter $\hat{\gamma}$ only reflect changes in the share of female workers associated with foreign acquisitions. We expect $\hat{\gamma}$ to be positive, that is, firms to employ a larger share of women after a foreign owner has taken control.

[17]The variables included as controls are the following: (1) (ln) total employment; (2) (ln) TFP (to control for time varying selection on firm size and productivity, respectively); (3) exporter status; (4) share of imported inputs; and (5) foreign presence in the sector (to control for time-varying selection on the international presence of these firms and potentially related productivity effects not captured by other variables); and (6) (ln) capital per worker (to control for time-varying capital intensity of the firm).

Second, as suggested by Guadalupe *et al.* (2012), we conduct a propensity score weighting regression to reflect differences in the probability of a firm being acquired based on prior characteristics. The estimated probability of being acquired, or the propensity score, $\hat{p}(X_{i,t-1})$, can be used to reweight the data. The idea of this approach is that plants that are underrepresented in the treated or control group are up-weighted and plants that are overrepresented in one of the groups are down-weighted. In order to estimate the average treatment effect of foreign ownership, i.e. the ATT, we follow Nichols (2008) and assign a weight equal to one to all acquired firms and a weight equal to $\hat{p}(X_{i,t-1})/\left(1-\hat{p}(X_{i,t-1})\right)$ to all potential controls (firms remaining under domestic control)[18].

Foreign-acquired firms hire more female workers

The results from the fixed effects and propensity score weighting estimations are presented in Table 1.8 and confirm our difference-in-differences matching results: foreign acquisition has a positive and significant impact on the share of female workers in the firm. The first column in each panel includes only firm and year fixed effects; the second adds the set of lagged controls; the third presents the propensity score re-weighted estimates.

The fixed effects specifications in Columns 1 and 2 of Panel A show that the share of skilled female workers is positively and significantly associated with foreign ownership. Column 1a shows that the share of skilled female workers in foreign-acquired firms is around 2.7 per cent higher than in firms that stay under domestic control. This estimate is robust to controlling for lagged firm characteristics (Column 2a). In the case of unskilled women, the fixed effects specifications (Columns 1b and 2b) show that the effect of foreign ownership is not statistically significant. Similarly,

[18] A discussion of alternative weights is presented by Nichols (2008).

Table 1.8: Fixed Effects and Propensity Score Weighting Regressions Results

Panel A: Share of skilled female workers			
	(1a)	(2a)	(3a)
Acquired	2.680***	2.715**	1.377***
	(0.957)	(1.208)	(0.271)
No. of obs.	60,401	44,607	44,640
R^2	0.008	0.007	0.872
Panel B: Share of unskilled female workers			
	(1b)	(2b)	(3b)
Acquired	-1.179	-0.947	1.042***
	(0.873)	(1.110)	(0.282)
No. of obs.	60,401	44,607	44,640
R^2	0.008	0.008	0.919
Panel C: Share of all female workers			
	(1c)	(2c)	(3c)
Acquired	-0.177	0.373	0.521***
	(0.503)	(0.575)	(0.174)
No. of obs.	60,401	44,607	44,640
R^2	0.003	0.002	0.958
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Selection controls		Yes	
Propensity score weighting			Yes

Standard errors are clustered by firms (in parentheses).

Selection controls described in footnote 15.

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

the effect of foreign ownership on the share of all women is not statistically different from zero when we use the fixed effects specifications (Columns 1c and 2c).

Columns 3a and 3b present the propensity score re-weighted regressions for the shares of skilled and unskilled employees, respectively. In the case of skilled female workers (Column 3a), we observe that the coefficient of 1.38 is lower than in earlier columns but is still highly significant, implying that firms employ a higher share of skilled female workers following foreign acquisition. In the case of unskilled women (Column 3b), we now observe a positive and significant effect of 1.04 per cent after foreign acquisitions. Finally, the share of women among all workers (Column 3c) is 0.5 per cent higher after foreign acquisition.

These results confirm our findings from the difference-in-differences matching estimates. Foreign-acquired firms hire relatively more female workers than they would have done had they remained domestic. The impact, though, is higher when considering only skilled women.

1.7 Competition and Taste-based Discrimination

As previously stated, theories of taste-based discrimination (Becker, 1957) suggest that market competition will reduce discriminatory practices due to the costs to firms' owners. Assuming that the differences in hiring practices for men and women occur because of discrimination, one can expect that, as competition increases, the number of female employees within firms should also increase.

Since exporting firms are exposed to greater competition, they may be less discriminatory. Hence, foreign acquisitions of exporting firms should not lead to big changes in female employment. As a way to test our hypothesis that stronger competition reduces female discrimination in the labour market, we perform a difference-in-difference estimation between foreign-acquired firms and non-acquired firms including

exporter status at $t-1$, i.e. the year before acquisition, as an explanatory variable. This variable takes a value of 1 if the firm was an exporter the year before its acquisition and 0 otherwise[19]. We also include a post-acquisition dummy (*post-acquisition*) taking the value of 1 for all years following acquisition, and an acquisition dummy (*acquired*) which is equal to 1 for foreign-acquired firms and 0 otherwise, as well as interaction terms between exporter status, the post-acquisition periods and acquired firms. We include all years available for the matched sample.

In Table 1.9 we can observe that the share of skilled female workers within acquired firms increases in the post-acquisition years by an amount equal to 3.71 percentage points. However, when the acquisition dummy is interacted with the post-acquisition variable and the exporter status at $t-1$, the effect is negative (-4.69 percentage points) and significant —at the 5 per cent significance level—. Therefore, if our hypothesis that foreign acquisition does not affect the share of female employees within exporting firms is correct, the sum of these two coefficients must be equal to zero. An F-test shows that this is true in our case (see bottom of Table 1.9). For unskilled female workers and for the total share of female workers, this effect is not observed.

[19]The total number of foreign-acquired firms that were non-exporters at $t-1$ is 55 (out 158), which represents around 35 per cent of the total acquired firms.

Table 1.9: Effect of Exporting Status on Female Employment within Foreign-acquired Firms

	(1)	(2)	(3)
	Skilled women	Unskilled women	All women
Post-acquisition	1.242	-2.238	-0.434
	(1.552)	(1.731)	(1.095)
Post-acquisition*Acquired	3.712**	0.867	-0.174
	(1.611)	(2.217)	(0.774)
Exporter at t-1	0.408	-0.490	-0.119
	(0.469)	(0.403)	(0.278)
Exporter at t-1*Post-acquisition*Acquired	-4.693**	-0.0918	-0.0989
	(2.005)	(2.535)	(1.211)
Constant	30.41***	21.31***	25.29***
	(0.0945)	(0.0829)	(0.0562)
Observations	34.805	34.805	34.805
F-test _b[Post-acquisition*Acquired]+_b[Exporter at t-1*Post-acquisition*Acquired]=0			
	F-stat	p-value	
	0.55	0.4591	

Standard errors are clustered by firms (in parentheses).

*,**, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

1.8 Conclusions

A large body of empirical literature highlights that multinationals have more skilled labour forces and pay higher wages than domestic firms. However, the issue of gender inequality is generally ignored. This chapter aims to shed some light on this issue by examining the causal relationship between foreign ownership and a plants's share of female workers, using a census of Chilean manufacturing plants. We identify causality by controlling for the possible endogeneity of plant ownership status, using a difference-in-differences approach in combination with propensity score matching (kernel matching).

Our results can be summarized as follows. First, the evidence on foreign acquisitions shows that foreign ownership leads to a significant increase in the share of skilled female workers at the acquired plants. The improvements become visible one year after the acquisition and continue in the subsequent period. Two years after acquisition, the share of skilled female employees is 6.63 percentage points higher in the acquired plants than in the control group. When considering the share of unskilled female workers, we observe that the effect of foreign ownership is not statistically different from zero for any of the years under consideration. These results highlight the importance of considering skills differences when evaluating the impact of foreign ownership on female employment.

Second, we present supporting evidence for the argument that competition may be the driving force behind the rise in the share of female employees after foreign acquisitions. Since exporting firms are exposed to greater competition, they may be less discriminatory. Hence, foreign acquisitions of exporting (domestic) firms should not lead to big changes in the share of female employees, which is exactly what we found, that is, exporters act less discriminating already prior to foreign acquisitions. This finding is consistent with the view that lack of discrimination may be a source of competitive advantage. Additionally, exporters may be more concerned about

international reputation, which may motivate them to be less discriminatory than non-exporters.

Our results suggest that FDI may be a key channel to avoid "waste of talent", by offering more job opportunities to skilled women. In this sense, we present evidence of a further channel through which FDI can stimulate economic growth of host countries.

Appendix A

Complementary Tables

Table A.1: Selected Emerging Market Economies: Net FDI Inflows (Percentage of GDP)

	1980	1990	2000	2013
Brazil	1.00	0.25	5.08	2.85
Chile	**0.72**	**1.97**	**6.46**	**7.26**
China (mainland)	0.02	0.86	3.41	1.33
India	0.04	0.07	0.77	1.47
Mexico	0.92	0.91	2.84	3.03
Russia	n.a.	n.a.	1.05	3.70
Developing Economies	0.29	0.89	3.77	2.84
Latin America	0.83	0.78	4.55	5.03

n.a. Not available.

Source: UNCTAD (2014).

Table A.2: Selected Countries: Gender Inequality Indicators 2009[a]

	Chile	Trinidad Tobago	Argentina	Brazil	Mexico	Colombia	Peru
GEM	**0.53**	0.80	0.70	0.50	0.63	0.51	0.64
Ranking in the GEM	**75**	14	24	82	39	80	36
Seats in parliament held by women[b,c]	**13.9**	26.0	37.7	9.6	36.0	13.6	21.5
Female senior officials and managers[b]	**23**	43	23	35	31	38	29
Female professional and technical workers[b]	**50**	53	54	53	42	50	47
Ratio of estimated female to male earned income	**0.42**	0.55	0.51	0.60	0.42	0.71	0.59

[a]Data are as of 28 February 2009, unless otherwise specified.

[b]Percentage of total.

[c]Data are for 2013.

Source: UNDP (2009) and UNDP (2014).

Appendix B

Testing the Reliability of the Propensity Score

Propensity score matching provides a reliable estimate of the effect of foreign ownership on the share of female workers if, conditional on the propensity score, the potential outcomes of the matched sample are independent of whether or not acquisition takes place. If this assumption is satisfied, then the pre-acquisition variables (X_{t-1}) used to estimate the propensity score, should has the same distribution for the acquired and non-acquired groups. As emphasized by Rosenbaum & Rubin (1983), a lack of balance usually indicates a misspecification of the model used to estimate the propensity score.

In order to assess whether our data satisfy this condition, we conduct some tests jointly known as balancing tests. Since there is no consensus in the current literature about which of the multiple versions of the balancing test is most appropriate in terms of its statistical properties, we perform a number of balancing tests that are suggested in the literature.

First, we employ a test suggested by Rosenbaum & Rubin (1985). It examines the standardized differences (or bias) between the treated group and the group of controls using the kernel matching process, for all the variables included in the estimation of the propensity score. The difference between nearest neighbour matching and kernel matching are that in the former, unmatched control group observations are discarded

and given zero weights, with some firms of the control group observations serving as the counter-factual for more than one treatment observation (so they have weights greater than one). In the latter case, no control group firms are given a zero weight, with firms from the control group who are more similar to treated firms (in terms of their propensity score) given more weight and control firms who are less similar to treated firms given less weight. The bias for a variable X is the difference between its (weighted) mean for the foreign-acquired firms and that for the matched control group sample, divided by the square root of the average of the variances of X in the treatment and comparison groups. If our balancing condition is satisfied, then the standardized difference will be low. Since there is no formal criterion as to how small a standardized bias should be, we follow Rosenbaum & Rubin (1985) and consider a bias lower than 20 (in absolute value) as sufficient to satisfy the balancing condition. As shown in the first column of Table B.1, all the variables satisfy this condition.

The second test we apply is also suggested by Rosenbaum & Rubin (1985). It is a simple t-test of the equality of the (weighted) means of the pre-acquisition variables between the treatment group and the control group. This test indicates that there is no statistically significant difference between the (weighted) means of any of the variables included in the matching process between the treated and comparison groups.

The results from the above tests suggest that the balancing condition is satisfied overall in our matching process.

Table B.1: Balancing Tests

	(1) Bias	(2) Treated group mean	(3) Control group mean	(4) t stats	(5) p-value
$\ln(\text{TFP})_{t-1}$	5.1	8.86	8.78	0.1810	0.670
$\ln(\text{Employment})_{t-1}$	12.7	3.74	3.60	1.4117	0.235
Female labour share_{t-1}	4.2	26.10	25.13	0.0545	0.815
Skilled female labour share_{t-1}	-8.3	29.31	31.12	0.2179	0.641
Imported inputs share_{t-1}	14.7	0.12	0.08	2.5570	0.110
Exporter dummy_{t-1}	1.8	0.22	0.22	0.0525	0.819
$\ln(\text{Capital per worker})_{t-1}$	9.6	8.47	8.32	0.3241	0.569
Foreign presence in the sector_{t-1}	9.5	0.17	0.15	0.9783	0.323
No. of obs. (weighted)	158	158	158		

Chapter 2

Does FDI Boost Skill Upgrading? Firm-level Evidence from Chile

2.1 Introduction

A large empirical literature has evaluated the impact of foreign firms on wages. Indeed, a large number of empirical studies have found that foreign affiliates pay higher wages than domestic firms in both developed and developing countries, even after controlling for size and other firm and sectoral characteristics[1]. Nevertheless, very little is known about the impact of foreign ownership on non-wage working conditions. Exceptions include Hijzen *et al.* (2010) and Harrison & Scorse (2010). The aim of this chapter is to shed light on the impact of foreign ownership on a non-wage employment condition, namely the provision of training to employees. This chapter argues that inflows of foreign direct investment (FDI) may stimulate domestic firms to invest more in training. In this sense, workers may find employment in a foreign firm more attractive.

There is evidence in the literature that multinational enterprises (MNEs) have superior knowledge and better managerial and organisational practices than local firms (see for instance Helpman *et al.* , 2004 and Bloom & Van Reenen, 2010). Additionally,

[1] For a complete literature review see e.g. Heyman *et al.* (2007).

there is evidence suggesting that MNEs transfer knowledge to their foreign affiliates (Arnold & Javorcik, 2009) and that foreign affiliates provide more training and spend more on training than domestic firms in developing countries (e.g. Filer *et al.* , 1994; Djankov & Hoekman, 2000; World Bank, 1997 and Narula & Marin, 2005) and in developed countries (eg. Purcell *et al.* , 1999; Sousa, 2001; and Koch & Smolka, 2017). In this sense, workers may find employment in foreign firm more attractive.

A beneficial spin-off effect onto the host country arises if the superior training practices of a foreign MNE stimulate local suppliers, customers and competitors to improve their own training policies. Competitive pressure from foreign firms may stimulate skill upgrading by local firms aiming to increase their competitiveness. Furthermore, MNEs may provide local producers with better inputs, that will require better-trained workers to use them properly. Finally, MNEs might encourage and support their local suppliers' efforts to train their workers in order to embrace higher standards, and therefore provide them with better services or inputs. In sum, inflows of FDI into the same, upstream or downstream sectors, may facilitate skill upgrading by domestic firms. In this way, as stated by Blömstrom & Kokko (2003: 4): "*FDI may be a particularly valuable source of new technology. It not only introduces new ideas but it also strengthens the human capital base needed to adapt these ideas to the local market*".

We examine the link between training provision by Chilean firms and the presence of foreign affiliates in the same industry as well as in the input-providing (upstream) and input-sourcing (downstream) industries in the same geographical region. We control for firm-level characteristics in order to control for time-varying heterogeneity. We also include firm, industry-year and region-year fixed effects in order to control for unobservable heterogeneity. There is, to the best of our knowledge, no study to date that attempts to determine whether there is a linkage between foreign presence in the same, upstream or downstream sectors, and the provision of training by domestic

firms.

Our analysis is based on firm-level data available from the Chilean Longitudinal Enterprise Survey (Encuesta Longitudinal de Empresas, ELE) produced by the Ministry of Economics for the period 2009-2015. As the survey is biannual, in practice we have a time span of four periods over six years.

Chile is a suitable choice for our analysis, first, because human capital formation in the workplace is still weak in Chile. The country has made significant progress in the area of human capital (OECD, 2015). However, these improvements have mainly been driven by formal education, rather than capital formation in the workplace. This fact is evident when we analyse the Global Human Capital Index (GHCI), which is constructed by the World Economic Forum to measure countries' human capital, according to individuals' ability to acquire, develop and deploy skills throughout their working life rather than simply during their formative years. *"Beyond formal learning, human capital is enhanced in the workplace through learning-by-doing, tacit knowledge, exchange with colleagues and formal on-the-job learning"* (World Economic Forum, 2017: 5). The index is constructed for 130 countries worldwide, among which, in 2017 Chile was ranked 53rd in the overall index, 23rd in the sub-index related to formal education, and 97th in the sub-index related to human capital formation in the workplace.

The second reason why Chile is suitable is that it is one of the emerging market economies with the greatest FDI inflows relative to GDP. Indeed, in terms of GDP, the net FDI inflows into Chile are greater than those flowing into all of the BRIC economies (Brazil, Russia, India and China) and into Mexico[2].

The contribution of this chapter is threefold. First, we analyse the impact of foreign firms on another non-wage working condition, namely, the provision of training.

[2] See Table A.1.

Second, we present evidence about a new channel through which FDI may have important spillovers to domestic firms. Third, our analysis relies on data covering all production sectors, and not only manufacturing as most of the literature evaluating FDI spillovers to domestic firms does.

We will first present evidence implying that foreign firms offer more training to their workers (both in terms of expenditure and number of trained workers) than domestic firms. Then, we will proceed to explore the presence of horizontal and vertical linkages between foreign and domestic firms, that is, whether domestic firms in the same industry than foreign firms or providing/buying inputs to/from foreign firms invest more in training. We find that Chilean firms buying and supplying inputs from and to foreign affiliates spend more on training. On the one hand, domestic firms receiving inputs from foreign firms have to invest in their human capital in order to adopt technologies embodied in inputs provided by foreign firms (Almeida & Fernandes, 2008). On the other hand, domestic firms supplying inputs to foreign affiliates must improve the quality of their products, which may explain their more extensive training practices. This result is in line with previous studies showing positive backward spillovers from foreign to domestic firms in terms of total factor productivity (Javorcik, 2004) and innovation (Javorcik *et al.* , 2017). Throughout this analysis, we do not find a statistically significant positive effect of foreign firms' presence in the same industry of domestic firms[3].

We show that our results are robust to changing the measure of training, altering the sub-sample of analysis, and estimating FDI spillovers in terms of employment share rather than output shares. Since our estimates control for firm-level fixed effects as well as industry-year and region-year fixed effects, and since FDI proxies enter the equation one-year-lagged, simultaneity concerns are attenuated.

Our results have important policy implications. Worker training can be a vehicle

[3]We only find a statistically significant negative effect when we estimate FDI spillovers at the national rather than regional level (see Table 2.6).

for promoting human capital enhancement and innovation. It can be expected to lead to higher productivity and profitability as a direct result of the employees' increased capacity to carry out their work. Additionally, better-trained workers are better equipped to absorb and utilise new technologies and process innovations. These effects will be beneficial not only to the firms in which the trained employees work, but also to the economy generally, stimulating economic growth in the host countries.

The rest of the chapter proceeds as follows. Section 2.2 presents the literature review. Section 2.3 details the data used for the analysis as well as our empirical strategy. Section 2.4 presents our results. Section 2.5 presents our robustness checks. Section 2.6 explores the possibility of heterogeneous effects. Section 2.7 evaluates the impact of foreign presence on R&D activities of local firms. Finally, section 2.8 concludes.

2.2 Related Literature

Our chapter is related to two strands of the economic literature. First, we contribute to the literature investigating the effects of FDI on working conditions in the host country. Most of the empirical literature investigating the role of FDI in working conditions has been devoted to analysing its effects on wages. Multinationals are generally found to pay higher wages, even after controlling for size and other firm and sectoral characteristics (Girma *et al.* , 2001; Lipsey & Sjöholm, 2004; and Görg *et al.* , 2007).

A minor share of the attention has been devoted to other working conditions such as job stability, opportunities for training and professional development. Two remarkable works analysing the effects of FDI on non-wage working conditions are Hijzen *et al.* (2010) and Harrison & Scorse (2010). The first study investigates how foreign ownership affects hours of work, job stability, union coverage and the probability of

receiving a wage equal to or lower than the minimum wage, using linked employer-employee data from Germany, Portugal, the UK, Indonesia and Brazil and a propensity score matching (combined with difference-in-differences estimator) methodology. The authors find that foreign acquisitions lead to higher wages and greater job stability, but have no significant effects on other working conditions. For their part, Harrison & Scorse (2010) analyse the impact of anti-sweatshop campaigns in Indonesia on wages and employment. They find that the campaigns led to large real-wage increases in the targeted enterprises, but had no significant effects on employment.

We contribute to this strand of the literature by analysing another non-wage working condition, namely the provision of training. According to Javorcik (2015) training is an important determinant for employees' motivation to work in foreign firms. In her words: *"from the worker's perspective, employment in a foreign affiliate may be more rewarding than employment in a local firm if the former offer more opportunities for training and professional development"* (Javorcik, 2015: 9).

There is some empirical evidence supporting the idea that MNEs provide and spend more on training than domestic firms in developing countries. For instance, Filer *et al.* (1994) found that foreign-owned firms in the Czech Republic spent 4.6 times more than domestic firms on training. Similarly, Djankov & Hoekman (2000) provide evidence that foreign multinationals offer more labour training than Czech firms, and that the effect is higher for fully owned foreign firms than for joint ventures. Gershenberg (1987) uses information from a survey of 72 managers in 41 manufacturing firms in Kenya to show that foreign firms provide about twice the duration of training as domestic firms. A study conducted by the World Bank (1997) focusing on Malaysia also shows that foreign-owned firms provide more training to their workers than domestic enterprises. More recently, Narula & Marin (2005) have found that foreign firms spend 85 per cent more in training than Argentinian firms. Mohamed *et al.* (2013) study the behavioural differences between the recruitment, training and

retention practices of domestic enterprises and those of MNEs in Brunei. Among other conclusions, they find that MNEs place more emphasis on training than local firms.

Multinationals are also found to provide more labour training in developed host countries. For instance, Sousa (2001) finds that multinationals are more likely to provide training, and also provide higher intensities of training than domestic firms in the UK, controlling for a number of workplace and sector-specific characteristics. In a more recent work, Koch & Smolka (2017) provide evidence of a significant increase in workers' training due to foreign acquisition in Spain over the period 1998-2013.

The aforementioned studies show, for a number of countries, that foreign firms provide more training than domestic firms. However, there is, to the best of our knowledge, no study to date that has attempted to determine whether there is an imitation effect in the training practices of domestic firms operating in the same sector as the foreign firms, or upstream or downstream sectors.

Second, we contribute to the extensive literature on FDI spillovers. This literature has almost exclusively focused on the link between the presence of foreign firms and the total factor productivity (TFP) of domestic firms. Empirical analyses evaluating the effect of foreign presence in the same sector as domestic firms (horizontal spillovers) have produced mixed results. Aitken & Harrison (1999), Javorcik (2004), and Javorcik and Spatareanu (2008 and 2011) find that the effect on TFP is either negative or statistically insignificant. Other authors have found a positive effect (Haskel *et al.* , 2007; and Keller & Yeaple, 2009)[4].

When the inter-sectoral effects (vertical spillovers) are analysed, most of the literature on developing countries finds evidence of vertical spillovers through backward linkages from foreign firms to domestic suppliers. Javorcik (2004) finds a positive effect of FDI on local firms in upstream sectors in Lithuania. Blalock & Gertler (2008)

[4]Chapter 3 presents evidence that horizontal spillovers can be non-linear, which may explain the different conclusions found in the literature.

find a similar effect in Indonesia and Javorcik & Spatareanu (2008 and 2011) in Romania. In contrast, forward spillovers are rarely found, one exception being Driffield *et al.* (2002), who report positive forward spillovers from MNEs using industry-level panel data for the UK manufacturing sector over the period 1984-1992. The main argument that may explain the lack of evidence of forward spillovers is that most of the production of foreign firms is exported, making their links with local firms in downstream sectors weak (Javorcik, 2004).

More recently, some authors have studied the presence of FDI spillovers in other outcomes of domestic firms. For instance, Javorcik *et al.* (2017) examine the relationship between foreign presence and product upgrading by Turkish manufacturing firms. They find that Turkish firms operating in sectors and regions more likely to supply foreign affiliates tend to introduce more complex products. We help to shed light on the different channels through which FDI inflows may affect the local economy by considering a different outcome, i.e. the provision of training to employees.

2.3 Data and Empirical Methodology

2.3.1 Data description

The data we use in our empirical analysis come from the ELE conducted by the Chilean Ministry of Economics. It characterizes productive, commercial and service firms operating in Chile. The ELE is a biannual survey and has been conducted in four years: 2009, 2011, 2013 and 2015. The survey includes information on roughly 7,500 firms each year. However, only around 5,000 firms have been present in at least two of the four waves of the survey, which allows us to construct an unbalanced panel data set.

The survey collects rich information on strategic firm decisions along with key

items from the firms' balance sheets. What makes the ELE data especially interesting for our analysis is that it not only records the ownership of the firm (foreign vs. domestic), but also specific information about the training practices of the firms, including the total expenditure on training and the total number of trained workers. The ELE data also provide detailed information that enables computation of the FDI spillover proxies.

The dataset distinguishes between 11 different industries at the one-digit level of the ISIC Rev. 4 classification and five different size groups defined by the average annual sales during the year; combinations of industries and size groups serve as strata in the stratification. Information about the geographical location of the firms is also provided. The dataset identifies 15 regions based on the geo-political division of Chile.

We express all value variables in constant 2014 prices using industry-level price indexes derived from the Chilean National Institute of Statistics (Instituto Nacional de Estadística, INE). As usual in the empirical literature we follow the OECD Benchmark Definition of FDI, which establishes that a firm can be considered foreign if at least 10 per cent of its capital is owned by foreign investors (OECD, 1999).

2.3.2 Measuring FDI spillovers

To capture the impact of foreign firms' presence on the provision of training to their workers by Chilean firms, we use the standard proxies for horizontal and vertical spillovers employed in the literature (see, e.g., Javorcik, 2004). Following Javorcik *et al.* (2017), we compute these proxies at the region-sector-year level, thus exploiting both regional and cross-industry variation in the presence of foreign-owned firms over time. Regions are defined following the geo-political division of Chile, with a total of 15 regions, whereas sectors are defined at the one-digit ISIC level, with a total of 11

production sectors.

Our spillover proxies are compiled based on the information on foreign firms, their sector of activity, location and output available from the ELE data. The proxy for horizontal (intra-industry) spillovers measures the relationship between domestic and foreign firms when they operate in the same sector j and region r at time t:

$$Horizontal_{jrt} = \frac{\sum_{i \epsilon jr} (Foreign\ Share_{it} * Y_{it})}{\sum_{i \epsilon jr} Y_{it}} \tag{2.1}$$

where $Foreign\ Share_{it}$ is the foreign-ownership share of firm i in region r, operating in sector j at time t, and Y_{it} denotes the output of firm i in year t. Therefore, $Horizontal_{jrt}$ can be defined as the output of foreign firms in a given sector-region cell as a share of the total output of that cell, in a given year.

$Backward_{jrt}$ is a proxy for the foreign presence in the sectors supplied by sector j in region r:

$$Backward_{jrt} = \sum_{k\ if\ k \neq j} \alpha_{jk} * Horizontal_{jrt} \tag{2.2}$$

where α_{jk} is the proportion of the output of sector j supplied to sector k, derived from the national input-output tables for intermediate consumption, for Chile, in the year 2013[5]. In other words, $Backward_{jrt}$ serves as a proxy for the potential linkages between foreign firms and their local suppliers.

$Forward_{jrt}$ is defined as the weighted share of the output of supplying sectors with a foreign presence:

$$Forward_{jrt} = \sum_{m\ if\ m \neq j} \sigma_{jm} * Horizontal_{jrt} \tag{2.3}$$

[5] Typically, final consumption is not taken into account.

In this case the coefficients σ_{jm} correspond to the share of sector j's inputs purchased from industries m. Therefore, $Forward_{jrt}$ measures the relationship between domestic and foreign firms when the domestic firm purchases inputs from the foreign firms.

Hence, $Backward_{jrt}$ captures foreign presence in sectors that purchase inputs from sector j, while $Forward_{jrt}$ measures the foreign presence in the sectors that sell inputs to sector j. Following Javorcik (2004), we exclude sourcing and supplying taking place within the same sector ($k \neq j$ and $m \neq j$, respectively) in order to separate intra-industry effects (measured by $Horizontal_{jrt}$).

2.3.3 Descriptive statistics

Table 2.1 shows a comparison of domestic and foreign-owned firms in Chile. We find considerable differences between the two groups, not just in terms of training measures, but also in their size, capital intensity and exporter status. As can be observed, foreign firms spend considerably more on training and train many more workers than domestic firms. Indeed, about 60 per cent of foreign firms offer training to their workers, while only 37 per cent of Chilean firms do. This finding supports previous evidence that foreign firms are more willing to train their workers than domestic firms. As expected, foreign firms are also larger, more capital intensive and more likely to be exporters than local firms. Regarding competition, foreign firms appear to operate in slightly less concentrated industries than domestic firms.

2.3.4 Empirical methodology

Our empirical strategy follows two steps. First, we estimate the effect of foreign ownership on training provision at the firm level. Second, we test the presence of spillovers from foreign firms to domestic firms in terms of their worker-skill upgrading

Table 2.1: Descriptive Statistics

	(1) Foreign firms	(2) Domestic firms	(3) All firms
Total expenditure on training $(\ln)_{it}$	5.516	2.831	3.108
	(5.714)	(4.696)	(4.880)
Total number of trained workers $(\ln)_{it}$	2.289	1.133	1.252
	(2.463)	(1.929)	(2.022)
Firm offering training to workers$_{it}$	0.603	0.371	0.395
	(0.489)	(0.483)	(0.489)
Horizontal$_{it}$	0.228	0.156	0.163
	(0.203)	(0.185)	(0.188)
Backward$_{it}$	0.304	0.285	0.287
	(0.353)	(0.341)	(0.342)
Forward$_{it}$	0.251	0.257	0.256
	(0.189)	(0.185)	(0.185)
Size$_{it}$	6.040	4.748	4.881
	(2.338)	(2.607)	(2.610)
Capital intensity$_{it}$	6.539	5.629	5.723
	(6.878)	(6.353)	(6.414)
Exporter status$_{it}$	0.419	0.128	0.158
	(0.494)	(0.334)	(0.364)
Herfindahl$_{it}$	0.205	0.254	0.249
	(0.288)	(0.294)	(0.294)
Observations	1531	13300	14831

Table reports variable means and standard deviations (in parentheses).

practices.

In order to test whether foreign firms provide more training and spend more on it than domestic firms, we estimate a simple OLS regression with the following specification:

$$T_{it} = \alpha_1 ForeignShare_{it-1} + \beta' X_{it-1} + \delta_{jt} + \mu_{rt} + \varepsilon_{ijrt} \quad (2.4)$$

where T_{it} is our measure of workers training. We use three alternative measures: total number of trained workers (ln), total expenditure on training (ln) and a dummy for firms offering training. Our explanatory variable of interest is the foreign ownership share of the firm ($ForeignShare_{it-1}$). We also control for a set of firm and sector specific characteristics (X_{it-1}), such as size (measured by the (ln) total number of workers), capital intensity (measured by the (ln) capital per worker), an indicator variable for its exporter status, and a Herfindahl concentration index. We also control for industry-year (δ_{jt}) and region-year (μ_{rt}) fixed effects in order to control for general time trends and industry and regional shocks.

Then, we evaluate the presence of spillovers from foreign firms to domestic firms located in the same, upstream and downstream sectors on the provision of training by domestic firms. We exclude the foreign firms for our estimates. We use the panel structure of our database and estimate a fixed effects regression with the following specification:

$$T_{ijrt} = \alpha_2 Horizontal_{jrt-1} + \alpha_3 Backward_{jrt-1} + \alpha_4 Forward_{jrt-1} + \beta' X_{it-1} + \gamma_i + \delta_{jt} + \mu_{rt} + \varepsilon_{ijrt} \quad (2.5)$$

where T_{ijrt} represents the total expenditure on training by firm i at year t, which is located in region r and whose main sector of activity is j. $Horizontal_{jrt-1}$ is a proxy for foreign presence in sector j of region r, which captures intra-sector-region spillovers. $Backward_{jrt-1}$ measures foreign presence in sectors receiving inputs from domestic firms (downstream sectors) operating in sector j of region r, and $Forward_{jrt-1}$ captures possible spillovers from foreign firms providing inputs to domestic firms operating in sector j and region r. In our empirical model, we control for a number of relevant firm-level characteristics (X_{it-1}). This set includes the same variables as in Equation (2.4), that is, firm (ln) size, capital intensity measured by the (ln) capital per worker, an indicator variable for exporting firms, and the Herfindahl concentration index at the sector-region level. We also control for firm fixed effects (γ_i) , and one-digit ISIC sector-year (δ_{jt}) and region-year (μ_{rt}) fixed effects. Including a firm fixed effect helps us to control for selection based on time-invariant firm characteristics, while the inclusion of the vector X_{it-1} controls for selection on time-varying observables. We also control for the possibility that foreign firms choose specific sectors and regions because of their attractiveness. Sector-year and region-year fixed effects also control for time-varying shocks such as regional or sectoral demand shocks.

All the explanatory variables are included in the specification with a one-year lag in order to mitigate simultaneity issues. Additionally, we cluster standard errors at the region-industry-year level, because our spillover proxies are calculated at this level.

2.4 Results

Our empirical results are also presented in two steps. First, we present the estimates of the effect of foreign ownership on training provision. Second, we provide the results of our test for the presence of spillovers from foreign firms to domestic firms in terms

of their worker-skill upgrading practices.

2.4.1 Foreign firms provide more training than domestic firms

We first test whether foreign firms provide more and spend more on training than domestic firms, by estimating Equation (2.4). The results are presented in Table 2.2. As suggested by the literature, e.g. Koch & Smolka (2017), foreign ownership has a positive impact on the provision of training to workers. The training increases as the share of foreign ownership goes up, both in terms of total number of trained workers (Column 1, Table 2.2) and total expenditure on training (Column 2, Table 2.2). An increase of 10 percentage points in the foreign share of the firm increases the total number of trained workers by 4.4 per cent and the total expenditure on training by around 10 per cent[6].

Firms with higher foreign ownership are also found to have a higher probability of offering training to their workers: an increase of 10 percentage points in the foreign ownership share leads to a rise in the probability of offering training of 0.61 per cent (Column 3, Table 2.2).

Nevertheless, our results do not persist when we incorporate firm-level fixed effects, probably because we have very few firms changing their ownership status from domestic to foreign within our sample. We also have a very short time-span (four years) which was reduced by the inclusion of lagged explanatory variables need to avoid simultaneity issues. However, we control for industry-year and region-year fixed effects which mitigates endogeneity concerns.

Our results also suggest that larger and exporting firms make a greater effort to train their workers. Indeed, the magnitude of the effect is very similar than the one for the foreign ownership share. The capital intensity of the firm also exerts a positive

[6]The results are obtained in the form $(e^{0.10\hat{\beta}}-1)*100$ where $\hat{\beta}$ is the estimated relevant coefficient.

effect on the skill upgrading of the firms. Additionally, as expected, firms operating in more concentrated (less competitive) industries are found to be less willing to upgrade the skills of their workers.

Table 2.2: Foreign Ownership and Training

	(1) Total number of trained workers(ln)	(2) Total expenditure on training (ln)	(3) Firms offering training to workers
Foreign_share$_{t-1}$	0.431***	0.952***	0.0610***
	(0.078)	(0.15)	(0.016)
Size$_{t-1}$	0.402***	1.058***	0.0727***
	(0.012)	(0.022)	(0.0021)
Capital intensity$_{t-1}$	0.0308***	0.0348***	0.0101***
	(0.0042)	(0.0092)	(0.0010)
Exporter$_{t-1}$	0.389***	0.924***	0.0841***
	(0.061)	(0.12)	(0.014)
Herf$_{t-1}$	-0.0388	-0.146	-0.0689***
	(0.099)	(0.17)	(0.025)
Industry-year FE	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes
Observations (firm-year)	8009	8009	8009
Number of firms	5196	5196	5196
R^2	0.3818	0.4774	0.2983

Robust standard errors (in parentheses).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

2.4.2 Spillovers to domestic firms

In order to evaluate the impact of foreign firms' presence in the same, upstream and downstream sectors, on the provision of training by Chilean firms, we estimate Equation (2.5). The results are presented in Table 2.3. The proxies for FDI presence in the same, upstream and downstream sectors are first included one by one (Columns

1 to 3), and then all together (Column 4). Our results suggest a positive relationship between the foreign presence in the upstream (forward spillovers) and downstream (backward spillovers) sectors and the expenditure on training by Chilean firms (both when these proxies are included in the specification by themselves and in the full specification). The size of the coefficients is similar across columns and slightly larger in the case of the full specification.

The magnitude of the effect is economically meaningful. A one-standard-deviation increase in the foreign presence in the sourcing sectors (that is, an increase of 0.34 percentage points in the backward variable) is associated with a 11 per cent rise in the expenditure in training of domestic firms operating in the supplying industries. In the case of forward spillovers, we find that an increase of one standard deviation in the forward variable is associated with a 4 per cent rise in the expenditure on training of each domestic firm in the demanding industries[7].

These results suggest that using better inputs supplied by MNEs requires better-trained workers, which motivates domestic firms to spend more on their training (positive forward spillovers). This finding is consistent with the need for Chilean firms to invest more in training in order to adopt better technologies (embodied in better inputs received from their foreign suppliers)[8]. Also, domestic firms providing inputs to MNEs are found to spend more on training their workers. MNEs may encourage their local suppliers to train their workers, and support such training, in order to enhance the quality of their output, which would be in line with other studies showing positive backward linkages from FDI to domestic firms in terms of productivity (e.g. Javorcik, 2004) and innovation (Javorcik *et al.* , 2017). However,

[7] The results are obtained in the form $(e^{sd*\hat{\beta}}-1)*100$ where $\hat{\beta}$ is the estimated relevant coefficient from the full specification (Column 4, Table 2.3).

[8] There is an extensive literature supporting the idea that technological innovations are embodied in inputs transferred from developed to developing countries through exports and multinationals. For instance, using firm-level data covering 43 developing countries, Almeida & Fernandes (2008) report that on average 53 per cent of the technological innovations are embodied in new machinery or equipment.

our results for backward spillovers are less statistically significant than our findings for forward spillovers[9].

Table 2.3: Total Expenditure on Training (ln): Spillovers from Foreign Firms

	(1)	(2)	(3)	(4)
Horizontal$_{t-1}$	0.0375			-0.116
	(0.37)			(0.38)
Backward$_{t-1}$		0.294*		0.317**
		(0.16)		(0.15)
Forward$_{t-1}$			0.199***	0.200***
			(0.072)	(0.072)
Observations	7144	7144	7144	7144
R^2	0.430	0.430	0.431	0.431
Firm FE	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Selection controls	Yes	Yes	Yes	Yes

Robust standard errors are clustered at the region-industry-year level (in parentheses).
*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

2.5 Robustness Checks

We subject our results to multiple robustness checks. First, we show that our results are not affected when using a different sub-sample or changing the proxies for foreign presence. We modify our sub-sample of analysis by changing the definition of foreign firms to those firms with a foreign ownership share equal to or higher than 50 per cent (rather than 10 per cent as in our baseline scenario). We also change our proxies for FDI spillovers by estimating our spillovers in terms of employment (rather than output) share.

Second, we use alternative definitions of training. Particularly, we use the total

[9]Local firms offering more training to their workers may also exhibit other production-upgrading activities. In the Appendix C, we present evidence supporting the idea that there are positive forward spillovers onto the probability that domestic firms will perform R&D activities.

number of trained workers (ln), the total expenditure per trained worker (ln), and the probability of offering training. Our finding of a positive effect of foreign firms' presence in sector-regions supplying inputs to local firms is confirmed under all three alternative measures of training. In the case of backward spillovers, these are only found to be significant when we use the total expenditure per trained worker.

Finally, we estimate our proxies for foreign presence at the national (rather than regional) level in order to discount the possibility that local firms may offer more training to their workers because MNEs are hiring the best employees within the region. In this case, we only confirm our baseline results for the local firms receiving inputs from MNEs (positive forward spillovers).

Overall, our more robust result is the presence of a positive effect from foreign presence in sectors more likely to provide inputs to domestic firms (i.e. positive forward spillovers).

2.5.1 Alternative definition of foreign firms and FDI spillovers

As mentioned above, in this robustness check, we change our definition of foreign firms to those with foreign ownership share equal to or higher than 50 per cent. In this sense, we change our sub-sample of analysis, since a larger number of firms are now considered domestic. Our results are confirmed: there are positive spillovers in terms of workers training onto domestic firms operating in sector-regions that are more likely to provide or to receive inputs to/from foreign firms (Column 1, Table 2.4).

Next, we compute our proxies for foreign spillovers in terms of employment (instead of output) share (Column 2, Table 2.4), and using the benchmark definition of a foreign firm. Again, we find that the presence of foreign firms promotes skill upgrading (through training of the labour force) by Chilean firms in both the demanding

and supplying industries. The magnitudes of the coefficients in both exercises are very similar to those obtained in the baseline estimates.

Table 2.4: Total Expenditure on Training (ln): Spillovers from Foreign Firms using Alternative Definition of Foreign Firms and FDI Spillovers

	(1) Alternative sub-sample	(2) Alternative FDI spillover proxies
Horizontal$_{t-1}$	-0.223	-1.045
	(0.40)	(0.73)
Backward $_{t-1}$	0.311**	0.306**
	(0.13)	(0.14)
Forward $_{t-1}$	0.203***	0.237***
	(0.072)	(0.067)
Firm FE	Yes	Yes
Industry-year FE	Yes	Yes
Region-year FE	Yes	Yes
Selection controls	Yes	Yes
Observations	7226	8486
R^2	0.497	0.397

Robust standard errors are clustered at the region-industry-year level (in parentheses).
*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.)

2.5.2 Alternative measures of worker training

Next, we apply four alternative measures of worker training: the total number of trained workers (ln), the share of trained workers (ln), the total expenditure per trained worker (ln), and a dummy variable for firms offering training to their workers. The results are presented in Table 2.5. We also include our baseline results in Table 2.5 (Column 1). As we can observe, the presence of positive forward spillovers from foreign firms to domestic firms is confirmed under all four alternative measures of training. An increase of one standard deviation in the forward variable is associated with a rise of one per cent in the total number of trained workers (Column 2), 4 per cent in the share of trained workers (Column 3), 3 per cent in the amount spent per trained worker (Column 4), and 0.3 per cent in the probability of a firm offering

training to its workers (Column 5).

In the case of backward spillovers, the coefficient is significantly positive in only one out of the four alternative measures of training, namely, the (ln) total expenditure per trained worker (Column 4). A one-standard-deviation increase in the backward variable increases by 11 per cent the total expenditure per trained worker in domestic firms. However, we do not have statistical evidence that domestic firms operating in sector-regions more likely to supply inputs to foreign affiliates differ from other domestic firms in terms of the total number of trained workers, the share of trained workers or the probability of offering training.

Table 2.5: Alternative Definitions of Training: Spillovers from Foreign Firms

	(1) Total expenditure in training (ln)	(2) Total number of trained workers (ln)	(3) Share of trained workers (ln)	(4) Total expenditure per trained worker (ln)	(5) Firm offering training to workers
Horizontal$_{t-1}$	-0.116	-0.0982	-0.209	-0.120	-0.0139
	(0.38)	(0.23)	(0.22)	(0.37)	(0.046)
Backward$_{t-1}$	0.317**	-0.0719	0.00965	0.312**	-0.00497
	(0.15)	(0.044)	(0.020)	(0.15)	(0.014)
Forward$_{t-1}$	0.200***	0.0496*	0.198***	0.154**	0.0160*
	(0.072)	(0.029)	(0.047)	(0.066)	(0.0082)
Firm FE	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes	Yes
Selection controls	Yes	Yes	Yes	Yes	Yes
Observations	7144	7144	7144	7144	7144
R^2	0.431	0.275	0.250	0.470	0.268

Robust standard errors are clustered at the region-industry-year level (in parentheses).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.)

2.5.3 National-level spillovers

It is possible that, as MNEs pay higher wages, they hire the best workers, drawing them away from local firms. This might mean that local firms have to spend more on training these workers who are not hired by MNEs in a determined region. Since our analysis relies on region-specific FDI spillovers, our results may be affected by this possibility. In order to evaluate this alternative hypothesis, we repeat our estimations using national-level spillovers. In this case, we clustered the standard errors at industry-year level.

As we can observe in Table 2.6, our main results continue to be valid even when computing the FDI spillovers at the national level. The presence of positive forward spillovers from foreign to domestic firms is confirmed (both when they are included in the specification by themselves (Columns 1 to 3) and in the full specification (Column 4). The magnitude of the effect is, however, smaller than when the spillovers are calculated at the regional level: an increase of one standard deviation in the forward variable leads to an increase of around 2 per cent in the total expenditure on training (while in the baseline estimation our result is twice this figure).

Regarding the presence of foreign firms in the sectors receiving inputs from local firms, we do not find a significant effect neither when the backward variable is included in the specification by itself nor in the full specification.

2.6 Possible Heterogeneous Effects of Foreign Presence in Upstream Sectors

Following Javorcik *et al.* (2017), we allow for heterogeneous effects of foreign presence in upstream sectors (forward spillovers) on training expenditure, depending on the local firm's pre-existing characteristics in terms of training, size and exporter status. We only explore the possibility of heterogeneous effects of the forward spillovers,

Table 2.6: Total Expenditure on Training (ln): National-level Spillovers from Foreign Firms

	(1)	(2)	(3)	(4)
Horizontal$_{t-1}$	-0.0127**			0.731
	(0.0048)			(0.64)
Backward $_{t-1}$		-0.0739		-0.0461
		(0.078)		(0.037)
Forward $_{t-1}$			0.104**	0.105*
			(0.041)	(0.057)
Firm FE	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Selection controls	Yes	Yes	Yes	Yes
Observations	8493	8493	8493	8493
R^2	0.330	0.331	0.333	0.333

Robust standard errors are clustered at the industry-year level (in parentheses).
*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.)

because this was our most robust effect we found in the earlier analysis. Table 2.7 summarizes the main results.

2.6.1 Domestic firms' pre-existing training

The benefits domestic firms receive from the presence of foreign firms in supplying sectors may depend on their initial capabilities, which can be captured by the firm's pre-existing expenditure on training. There are two possible outcomes. On the one hand, local firms with higher pre-existing levels of training may be better prepared to incorporate new inputs supplied by foreign firms, and therefore experience larger spillovers. On the other hand, there may be a catch-up effect for local firms with lower pre-existing levels of training expenditure, implying that, once exposed to the availability of inputs produced by foreign firms, these local firms may need to spend more on training in order to incorporate such inputs in their production processes. In

order to evaluate these possibilities, we extend our baseline specification (Equation 2.5) by including the interaction between forward spillovers and a dummy denoting domestic firms with pre-existing training expenditure above the sample median. The estimated coefficient on the interaction term is negative and statistically significant (Column 1, Table 2.7), suggesting that domestic firms with lower pre-existing levels of training are the ones that benefit most from a foreign presence in upstream sectors. Therefore, such a presence seems to contribute to the convergence in the skills upgrading of the labour force among domestic firms. This result is in line with the finding of Javorcik *et al.* (2017) for innovation of Turkish firms.

2.6.2 Firm size and exporter status

Firm size may also affect the extent to which domestic firms benefit from the presence of foreign firms in upstream sectors. Therefore, we include an interaction term between the forward spillover proxy and either a dummy denoting firms whose number of employees is above the median of the sample (168 workers) or a dummy denoting firms above the 75th percentile (more than 936 employees). In the first case, the estimated coefficient for the interaction term is negative but not statistically significant (Column 2, Table 2.7). However, the estimated coefficient of the interaction term when we use the dummy indicating firms with more than 936 employees (Column 3, Table 2.7) is negative and statistically significant at the 5 per cent level. Namely, larger firms benefit less from a foreign presence in upstream sectors.

The exporter status of domestic firms does not seem to affect the magnitude of the spillovers from FDI in upstream sectors. As can be observed in Column 4 of Table 2.7, the estimated coefficient of the interaction term between forward spillovers and a dummy denoting exporter firms is not statistically significant.

Table 2.7: Total Expenditure in Training (ln): Heterogenous Effects of Forward Spillovers

	(1) Pre Training	(2) L>168 employees	(3) L>936 employees	(4) Exporter
Horizontal $_{t-1}$	0.355	-0.0269	-0.0250	0.000259
	(0.39)	(0.37)	(0.37)	(0.38)
Backward $_{t-1}$	0.115	0.280*	0.284**	0.283*
	(0.094)	(0.14)	(0.15)	(0.15)
Forward $_{t-1}$	0.668***	0.206***	0.239***	0.203***
	(0.22)	(0.074)	(0.076)	(0.075)
Forward $_{t-1} \times$ D$^{T\ high}$	-0.566**			
	(0.28)			
Forward $_{t-1} \times$ D$^{L\ high}$		-0.0777	-0.124*	
		(0.13)	(0.063)	
Forward $_{t-1} \times$ D^{Exporter}				-0.134
				(0.15)
Firm FE	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes
Region-year FE	Yes	Yes	Yes	Yes
Selection controls	Yes	Yes	Yes	Yes
Observations	7144	7144	7144	7144
R^2	0.473	0.452	0.460	0.452

Robust standard errors are clustered at the region-industry-year level (in parentheses).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

2.7 R&D Activities of Local Firms: Spillovers from Foreign Firms

In Section 2.4 we showed that the presence of foreign firms in upstream and downstream industries has a positive impact on the training local firms provide to their employees. That is, we found evidence of the presence of vertical (forward and backward) spillovers (Table 2.3). As local firms train their workers more, one should also expect some other production-upgrading practices, such as higher R&D.

We thus evaluate whether the presence of foreign firms in sectors providing or receiving inputs to/from local firms has an effect on the probability of performing R&D activities by domestic firms. To do so, we estimate the probability they perform R&D activities using a logit model that includes foreign firms' presence in the same, upstream and downstream sectors, as explanatory variables. We also control for a number of relevant firm-level characteristics, including firm size, capital intensity measured by (ln) capital per worker, an indicator variable for exporting firms, and the Herfindahl concentration index at sector-region level. We also control for firm fixed effects. Additionally, in order to mitigate endogeneity concerns, all our explanatory variables are included in our specification one year lagged.

The results are presented in Table 2.8. Our results suggest a positive relationship between a foreign presence in the upstream sectors (forward spillovers) and domestic firms' probability of performing R&D. For every increase of one percentage point in the forward measure, the probability that local firms carry out R&D increases by 30 per cent. We do not find evidence of the presence of backward spillovers.

2.8 Conclusions

In this chapter, we examine whether FDI inflows can stimulate worker training in the host country's firms. More precisely, we use firm-level data from Chile over the

Table 2.8: R&D Activities of Local Firms: Spillovers from Foreign Firms

	(1)
Horizontal $_{t-1}$	1.584*
	(0.82)
Backward $_{t-1}$	0.0577
	(0.078)
Forward $_{t-1}$	0.300***
	(0.073)
Size_{t-1}	0.623***
	(0.14)
$\text{Capital intensity}_{t-1}$	-0.535***
	(0.045)
Exporter_{t-1}	-0.812
	(1.20)
Herf_{t-1}	-5.435***
	(0.67)
Firm FE	Yes
Industry-year FE	No
Region-year FE	No
Selection controls	Yes
Observations	3435

Standard errors (in parentheses).

*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

period 2009-2015 to analyse the link between workers' training provided by Chilean firms and the regional presence of foreign affiliates in the input-sourcing and input-demanding sectors. We find evidence implying that foreign firms have positive effects on the training practices of Chilean firms operating in sectors receiving or supplying inputs from or to multinationals. This positive effect seems to be more robust for the case of Chilean firms receiving inputs from foreign affiliates. This finding may reflect domestic firms' need to upgrade the skills of their workers in order to incorporate the better technologies embodied in the better inputs provided by multinationals. Consistent with the broad conclusions of the FDI spillover literature, we find no evidence of any impact of FDI presence in the same sector as the local firm. We also present evidence that foreign firms have positive effects on the R&D activities of domestic firms operating in sector receiving inptus from multinationals, namely, positive forward spillovers.

Our conclusions support the view that attracting FDI inflows by emerging markets may have an important positive impact on their economic growth, in particular through enhancing the stock of human capital available in the host country. In addition, we present evidence that FDI contributes to the convergence of smaller firms and of those with less initial employee training.

Chapter 3

Distance to the Technological Frontier and Productivity Spillovers from FDI: The Case of Chilean Manufacturing

3.1 Introduction

In the past decades the rate of growth of foreign direct investment (FDI) inflows has been rapid. According to data from the United Nations Conference on Trade and Development (UNDP, 2014), in 1990 world FDI inflows were at USD 208.2 billion (0.95 per cent of world GDP), while in 2013 this amount had reached USD 1,452 billion (1.95 per cent of world GDP).

A large part of the FDI flows into developing countries. Indeed, between 1990 and 2013 inflows into developing countries increased from less than one per cent of GDP to 2.8 per cent[1]. Chile has not been excluded from this process. For instance, in 1990 FDI inflows into Chile were at USD 0.66 billion (1.92 per cent of Chilean GDP), while this figure had increased to USD 20.2 billion by 2013 (7.3 per cent of Chilean GDP).

Many developing countries have applied fiscal incentives in order to attract inward FDI with the aim of affecting economic growth via technological transfers or spillovers. Nevertheless, empirical evidence about the gains in productivity growth of developing countries due to FDI is ambiguous. For instance, Javorcik (2004), Chakraborty &

[1]FDI inflows into developing countries were at USD 35 billion in 1990, and at USD 778.3 billion by 2013 (UNCTAD, 2014).

Nunnenkamp (2008), and Suyanto *et al.* (2009) find evidence of positive productivity spillovers for Lithuania, India and Indonesia, respectively. On the other hand, Aitken & Harrison (1999) and Djankov & Hoekman (2000) find a negative relationship between FDI and productivity spillovers in Venezuela and the Czech Republic, respectively.

Görg & Greenaway (2003) summarize the results of 40 studies on productivity spillovers from FDI. Of those, only 19 find statistically significant and positive spillover effects[2]. However, most of them (11 studies) employ cross-sectional data which make the results less accurate, and the remaining pieces of research use panel data for industrial countries. Therefore, evidence about productivity spillovers in developing countries is scarce. This chapter contributes towards filling this literature gap by providing an explanation for the ambiguity of the relationship between FDI and productivity spillovers in developing countries.

Particularly, we suggest that the diverse results on productivity (intra-industry) spillovers from FDI are related to the distance to the technological frontier (DTF), and more importantly that the relationship between productivity spillovers and the DTF is nonlinear. We are not the first to provide such an explanation, but, to best of our knowledge, we are the first to test this hypothesis using panel data from a developing economy (Chile).

Therefore, the aim of this chapter is to examine the relationship between the DTF and productivity spillovers using plant-level data from Chilean manufacturing over the period 1995-2006. Our hypothesis is that domestic firms with lower DTFs are more likely to benefit from FDI. In order to test this hypothesis, we estimate a productivity growth equation that incorporates an interaction term between FDI and the DTF. Nevertheless, the relationship between spillovers from FDI and the DTF may be nonlinear; this is our second hypothesis. To address this second hypothesis,

[2]See Table 2 in Görg & Greenaway (2003) for a complete list of references.

we incorporate in the model a quadratic interaction term between FDI and the DTF.

Careful attention is paid to the issue of productivity measurement and the robustness of results across a variety of econometric specifications. We estimate total factor productivity (TFP) following the generalized method of moments (GMM) suggested by Wooldridge (2009). This methodology controls for both endogeneity and selection biases. Additionally, the estimations obtained using this approach are efficient. We also control for firm fixed effects in order to control for unobservable heterogeneity. In order to mitigate endogeneity concerns, all our explanatory variables are included in our specification one year lagged.

Our analysis yields two main conclusions. Firstly, the DTF is an important determinant of the ability of domestic firms to benefit from FDI. Indeed, domestic firms need not be too far away from the technological frontier for their productivity growth as a consequence of an increase in FDI to be raised. Secondly, we find an inverse U-shaped relationship between spillovers from FDI and the DTF. Namely, reductions in the DTF of domestic firms lead to higher FDI-related productivity growth up to a maximum level, beyond which productivity growth starts to decrease. In other words, the marginal effects of FDI on productivity growth are lower for firms closer to the technological frontier. Moreover, there is a maximum distance from the technological frontier from which productivity spillovers from FDI are absent or even negative.

Relative to the existing literature, the contribution of this chapter is twofold. First, we are not aware of any other study that provides evidence about a non-linear relationship between FDI spillovers and the DTF using panel data from a developing country. Previous evidence relies on data from developed economies, and studies of emerging economies apply cross-sectional data. Second, we improve upon previous studies by relying on unbiased firm-level TFP estimates, obtained as residuals from production functions estimated following the GMM approach suggested by Wooldridge (2009). This procedure not only controls for endogeneity and selection biases, but also cor-

rects for multicollinearity problems, outlined by Ackerberg *et al.* (2015), present in the widely used estimation procedures of Olley & Pakes (1996) and Levinsohn & Petrin (2003).

The remainder of this chapter is organized as follows. Section 3.2 incorporates some stylized facts related to the importance of FDI flows into Chile. Section 3.3 presents a critical literature review regarding the productivity spillovers from FDI in the manufacturing sector of the host country, giving especial attention to the role of the DTF as a mediating factor. Section 3.4 describes the database employed in this chapter, as well as the empirical methodology. Section 3.5 analyses the main empirical results. Section 3.6 concludes.

3.2 Why Chile? Some Stylised Facts

There are several reasons why the Chilean manufacturing sector is worthy of study. First of all, Chile is one of the most successful examples of a fast-growing emerging market economy. Second, due to the structural reforms undertaken by the military government in the 1980s (trade and financial openness, privatization of state-owned enterprises, the establishment of a new pension system, and the enforcement of fiscal and monetary responsibilities), the Chilean economy suffers from very few market distortions. Indeed, during the period under consideration (1995-2006) the country has not faced any political breaks. Finally, the political stability of the country, together with its economic conditions, facilitates the inflows of FDI.

During Allende's socialist government (1970 to mid-1973), Chile was virtually closed to FDI. Indeed, due to the risk of nationalization, many foreign investors moved their capital out of the country. After the military coup of September 1973, FDI started to flow back into the country as a consequence of the restoration of a

market economy, and the implementation of deep structural reforms[3] (Figure C.1). Incoming FDI has maintained an upward trend, giving Chile widespread international recognition for its success in attracting FDI. According to data from UNCTAD (2014), Chile has been one of the emerging market economies with the highest FDI inflows relative to GDP since 1990[4]. Indeed, in terms of GDP, the net FDI inflows to Chile are greater than in any of the BRIC economies (Brazil, Russia, India and China) and Mexico. As illustrated in Figure C.2, net FDI inflows represented 7.26 per cent of Chilean GDP in 2013.

In terms of the distribution of FDI among sectors (Figure C.3), according to data from the Chilean Committee of Foreign Investment, over the period 1974-2008 the mining sector accounted for about 34 per cent of gross FDI stock. It was followed by the electricity, gas and water industries (21 per cent), services (19 per cent), manufacturing (12 per cent), transport and communications (11 per cent), construction (2 per cent), and agriculture, forestry and fishing (1.5 per cent). The FDI inflows to the manufacturing sector reached their peak at the end of the 1970s. Manufacturing represented 58 per cent of the gross FDI stock over the period 1974-1978. This is mainly explained by the fact that, in that period, more than 600 enterprises –including many manufacturing firms– were privatized (Chumacero *et al.* , 2007). This figure decreased to its current level after the large inflows –into the mining sector in the 1980s and into the utilities sector in the 1990s– came to an end. Nevertheless, manufacturing continues attracting an important fraction of the FDI inflows.

[3] According to Chumacero *et al.* (2007) the military government secured property rights and established clear and unchanging "rules of the game", factors that explain the return of foreign investors to the country.

[4] See table Table A.1.

3.3 Literature Review

The basic assumption of micro-level models exploring the effects of FDI on host countries is that foreign firms have non-tangible assets (such as technological know-how, marketing and managerial skills) that can be transferred to domestic firms. This transmission of knowledge may occur through a number of different channels: imitation, competition, labour turnover, market access, and vertical linkages (Görg & Greenaway, 2003). However, evidence about the presence of positive spillovers is not conclusive. For instance, Aitken & Harrison (1999) and Djankov & Hoekman (2000) find a negative relationship between FDI and productivity spillovers in Venezuela and the Czech Republic, respectively. On the other hand, Chakraborty & Nunnenkamp (2008), and Suyanto *et al.* (2009) find evidence of positive productivity spillovers for India and Indonesia, respectively.

An explanation for the diverse conclusions in studies about spillovers from FDI is that most of them rely on horizontal effects, i.e. they only explore the potential gains of firms within the same industry as the foreign multinationals, but ignore the gains in productivity of domestic firms operating in other sectors (vertical spillovers). The main reason why domestic firms can experience null or negative horizontal spillovers from FDI is that domestic firms and multinationals operating in the same sector compete against one another. Thus, multinationals have incentives to avoid technological transfers and spillovers. In other words, knowledge spillovers from FDI can be counterbalanced by the competition effect (Aitken & Harrison, 1999).

Javorcik (2004) finds evidence of positive spillovers from FDI through backward linkages, but no evidence of forward linkages from FDI in Lithuanian manufacturing firms[5]. Positive FDI spillovers through backward linkages have also been reported for many other developing countries: Indonesia (Blalock & Gertler, 2008), Hungary

[5]Backward linkages refers to spillovers from foreign firms to their suppliers, while forward linkages refers to spillovers from foreign firms to their customers.

(Schoors & van der Tol, 2002), Romania (Javorcik & Spatareanu, 2008), Zambia (Bwalya, 2006), Mexico (López-Córdova, 2003) and Chile (López & Südekum, 2009)[6].

Another explanation for the empirical inconclusiveness of productivity gains from FDI is that *"countries and firms within countries might differ in their ability to benefit from the presence of foreign-owned firms and their superior technology"* (Lipsey & Sjöholm, 2004: 24). This line of research has tried to identify the necessary conditions that guarantee that host country firms can take advantage of the spillovers generated by inward FDI, i.e. the necessary mediating factors. The main mediating factors that the literature has identified are geographic proximity and the DTF. Since the aim of this chapter is to examine the role of the DTF in determining the magnitude of productivity spillovers from FDI, we review in detail the main studies that analyse this topic.

The role of the DTF as a mediating factor

Empirical evidence broadly supports that domestic firms can only benefit from FDI if their DTF is not too great to allow them to absorb the technology transferred by multinationals. Hence, the lower the DTF, the higher is the potential for positive spillovers. For instance, using cross-sectional industry-level data for Mexico, Kokko (1994) finds no evidence of FDI spillovers in industries where the technological gap between foreign and domestic firms is very large. Indeed, he concludes that industries with large technological gaps and a high foreign presence experience lower spillovers than others.

Girma *et al.* (2001) use firm-level panel data to examine productivity spillovers in the UK manufacturing sector. They find no evidence of FDI spillovers under the assumption that spillovers are homogenous across different types of domestic firms

[6]See Havranek & Irsova (2011) for a complete literature review on productivity spillovers from foreign firms to local firms in upstream and downstream sectors.

(in terms of their DTFs). However, when they control for the DTFs of domestic firms they find that firms with DTFs lower than 10 per cent increase their productivity as a consequence of a foreign presence.

Some authors have also reported that firms very close to the technological frontier do not benefit from a foreign presence. For instance, using cross-sectional firm-level data for Uruguay, Kokko *et al.* (1996) divide Uruguayan manufacturing firms according to their DTFs (measured as the difference between the firm's labour productivity and the average labour productivity in foreign firms). They find that spillovers are present only when the DTF is "moderate". That is, neither firms with very low nor those with very large DTFs benefit from an increase in FDI.

Similarly, in a study of micro-data for the UK electronics industry, Girma & Wakelin (2007) show that plants with larger DTFs do not benefit from FDI. However, they also find that establishments with very low DTFs do not see improved their productivity in the presence of foreign firms.

The results of Kokko *et al.* (1996) and Girma & Wakelin (2007) suggest that the relationship between FDI spillovers and the DTF may be non-linear. That is, the spillovers from FDI may not be monotonically increasing (or decreasing) with the DTF. For this reason, Girma & Görg (2005) and Girma (2005) suggest the incorporation of a quadratic interaction term between FDI spillovers and the DTF in empirical estimations.

3.4 Data and Empirical Methodology

3.4.1 Data description

The data used in this chapter come from the Annual National Manufacturing Survey (ENIA, by its Spanish acronym) collected by the National Institute of Statistics of Chile (INE, by its Spanish acronym). This survey includes all Chilean manufacturing

plants with at least ten workers, around 5,000 plants[7] per year. The data constitutes an unbalanced panel covering the period 1995-2006.

The survey captures information on different aspects of firm structure, that of interest to this chapter being the data related to production (gross nominal output, value-added, investment, intermediate inputs, capital and employment), as well as the ownership structure of the firm. The latter allows us to distinguish between foreign and domestically owned firms. As usual in the literature, we define foreign firms as those for which at least 10 per cent of total capital is foreign-owned[8].

The INE also reports the four-digit level price deflators for the gross nominal output and the intermediate inputs (separated by materials and energy), which enables us to obtain these variables at constant 2003 prices (INE, 2009). Additionally, we can compute the value-added at constant 2003 prices by using double deflation. Capital stock is obtained using the perpetual inventory method, and expressed in constant prices using implicit capital stock deflators, constructed as the ratio of current net capital stock to constant net capital stock obtained from Henríquez (2008). Labour is expressed as the number of workers, and divided into skilled and unskilled.

The data were subjected to the following cleaning process. We exclude tobacco (ISIC 314), petroleum refining (ISIC 353) and manufacture of products of petroleum (ISIC 354) from the sample because of a lack of representation (less than five firms operating in the sector). Wholesale trade (ISIC 610) and business services (ISIC 832) were dropped because they are not involved in manufacturing. Additionally, we merged iron and steel (ISIC 371) with non-ferrous metal basic industries (ISIC 372).

[7] As previously stated, although a plant is not necessarily a firm, Pavcnik (2002) points out that more than 90 per cent of Chilean manufacturing firms are single-plant.

[8] See for instance Javorcik (2004).

3.4.2 Empirical methodology

Empirical studies on FDI spillovers usually regress firm productivity on different explanatory variables, including some measure of foreign presence in the industry. As stated by Girma & Görg (2005), this implies that all firms benefit equally from FDI. In contrast, we allow the spillovers from FDI to differ across firms according to their DTFs (as defined below). Our hypothesis is that firms with lower DTFs benefit more from FDI because they are able to incorporate the knowledge transmitted by multinationals more easily.

In order to examine the role of the DTF as a mediating factor in the transmission of productivity spillovers from FDI, we estimate two models. The first one assumes that the relationship between spillovers from FDI and the DTF is linear, and the second assumes that it is quadratic. We estimate both models including firm and year fixed effects in order to control for unobserved heterogeneity. Additionally, in order to mitigate endogeneity concerns, all our explanatory variables are included in our specification one year lagged.

Specifically, to investigate the role of the DTF as a mediating factor, we evaluate the impact of spillovers from FDI on firm's productivity growth via the following TFP growth equation:

$$dln(TFP_{ijt}) = \alpha + \beta_1 DTF_{ijt-1} + \beta_2 Herf_{jt-1} + \delta(DTF_{ijt-1})FDI_{jt-1} + \alpha_i + \alpha_t + \varepsilon_{ijt} \tag{3.1}$$

where $dln(TFP_{ijrt})$ represents the growth of the (ln) TFP of firm i, operating in sector j at time t, which is computed as a residual following Wooldridge (2009). Further details about this methodology are given below. DTF_{ijt-1} indicates the distance to the technological frontier, where the frontier is measured as the maximum TFP within the four-digit industry (TFP^*_{jt-1}). In other words,

$$DTF_{ijt-1} = 1 - \frac{TFP_{ijt-1}}{TFP^{*}_{jt-1}} \tag{3.2}$$

DTF_{ijt-1} lies between 0 and 1, where 0 indicates that the firm is the technological leader. Therefore, the lower the DTF the closer to the technological frontier is firm i.

The Herfindahl index ($Herf_{jt-1}$) is included as a proxy for the level of four-digit industry concentration. The index is defined as the sum of the squared market shares of the four largest firms in a given sector. The index takes values between 0 and 1, where 0 indicates a perfectly competitive industry, while 1 indicates a monopoly. It is expected that firms operating in industries with a higher market concentration will have lower (ln) TFP growth rates, since the lack of competence may hinder improvements in productivity growth.

FDI_{jt-1} captures the foreign presence in the firm's four-digit industry j at time t. Following Javorcik (2004) we define it as the foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output. That is,

$$FDI^{Q}_{jt-1} = \frac{\sum_{i:\, i \epsilon j} foreign_share_{it} \times y_{it}}{\sum_{i:\, i \epsilon j} y_{it}} \tag{3.3}$$

where $foreign_share_{it}$ measures the share of the firm's total equity that is owned by foreign investors. In order to check the robustness of our results we use two other alternative measures of FDI: the importance of foreign firms for sectoral employment (which we denote FDI^{L}_{jt-1}), and for sectoral capital (which we denonte FDI^{K}_{jt-1}), both computed similarly to Equation (3.3). We also incorporate firm and time fixed effects (α_i, α_t) to control for unobserved factors that may affect the correlation between firm productivity and foreign presence. Finally, ε_{ijt} is a random error term.

In order to allow for the presence of possible non-linearities, we follow Girma (2005) and define the parameter capturing the spillovers from FDI (δ) as a quadratic function of the firm's DTF, that is,

$$\delta = d_0 + d_1 DTF_{ijt-1} + d_2 DTF^2_{ijt-1} \tag{3.4}$$

It is straightforward to note that when $d_2 = 0$ we have the linear interaction model, while when $d_2 \neq 0$ we have the quadratic form. Thus, the equations to be estimated are the following:

$$\begin{aligned} dln(TFP_{ijt}) = \quad & \beta_1 DTF_{ijt-1} + \beta_2 Herf_{jt-1} + d_0 FDI_{jt-1} \\ & + d_1(FDI_{jt-1} \times DTF_{ijt-1}) + \alpha_j + \alpha_t + \varepsilon_{ijt} \end{aligned} \tag{3.5}$$

$$\begin{aligned} dln(TFP_{ijt}) = \quad & \beta_3 DTF_{ijt-1} + \beta_3 Herf_{jt-1} + d_0 FDI_{jt-1} \\ & + d_1(FDI_{jt-1} \times DTF_{ijt-1}) + d_2(FDI_{jt-1} \times DTF^2_{ijt-1}) \\ & + \alpha_j + \alpha_t + \varepsilon_{ijt} \end{aligned} \tag{3.6}$$

The direct effect of FDI on productivity growth is captured by the parameter d_0, and the effects through its interaction with the DTF are given by the parameters d_1 and d_2. Equations (3.5) and (3.6) are estimated for all non-frontier domestic firms. The advantage of using a quadratic specification is that it avoids the assumption that the spillovers increase (or decrease) monotonically with the DTF. Indeed, the turning point at which the marginal effect of FDI on productivity growth starts to increase (or decrease) in magnitude is reached when the DTF equals its critical value $\rho = -(d_1/2d_2)$.

An unbiased measure of TFP

As is usual in the literature, TFP is estimated as the residual of the production function. However, accurate production function estimation at the firm-level is not

a trivial task, since traditional ordinary least squares (OLS) estimates suffer from simultaneity and selection biases. There is a positive correlation between unobserved productivity shocks and input levels, which causes a simultaneity problem between output and inputs. Additionally, adverse productivity shocks may induce firms to exit the market, so that only the more productive firms survive, leading to a selection bias. These two problems cause that the traditional OLS estimators of input coefficients to be both biased and inconsistent.

Several solutions to the problem have been introduced and the most popular of these are the structural two-step estimators by Olley & Pakes (1996) [henceforth OP] and Levinsohn & Petrin (2003)[9] [henceforth LP]. The main difference between the two approaches is that OP propose using the investment as a proxy for the unobserved productivity shocks, while LP suggest the use of intermediate materials as a proxy.

The LP approach has gained favour among empirical studies since it has three main advantages over the OP approach. First, since almost all firms report intermediate material expenditure, but not all report investment, applying LP avoids having to drop all firms with zero investment. Second, a firm with an intermediate input expenditure equal to zero is indeed not operating. Therefore, the use of LP indirectly controls the selection bias, avoiding the construction of an exit dummy variable as in OP. The third advantage is that there is a Stata command for implementing LP, developed by Petrin *et al.* (2004).

Nevertheless, as reported by Ackerberg *et al.* (2015) [ACF, hereafter], the OP and LP approaches suffers from collinearity in the first stage, which implies that the labour coefficient is not identified. ACF suggest a hybrid of the OP and LP approaches, which solves the identification problem under certain assumptions about the timing of a firm's decisions regarding input choice. Particularly, they assume that firms choose labour input after the capital stock is determined (via investment), but

[9]Eberhardt & Helmers (2010) provide a detailed survey of the different methods available for dealing with the simultaneity bias in firm-level production estimations.

before the intermediate inputs are chosen.

Although the AFC approach corrects the identification problem of the OP and LP approaches, it is still a complicated two-step estimator. For this reason, Wooldridge (2009) demonstrates that the OP and LP models can easily be estimated in a single step using a GMM framework, which provides important efficiency gains.

Our preferred estimator is Wooldridge (2009), using intermediate materials as proxy of unobserved productivity shocks[10]. This approach has several advantages over previous two-step estimators. First, it addresses the identification critique from ACF, which permits the user to identify all the production inputs parameters. Second, unlike the two-step estimators, Wooldridge's GMM estimator is efficient. Two-step estimators are inefficient because they ignore the contemporaneous correlation in errors across equations, and do not consider serial correlation or heteroskedasticity in the errors. In contrast, the GMM uses information from the correlation across equations and an optimal weighting matrix, which efficiently accounts for serial correlation and heteroskedasticity (Wooldridge, 2009: 113). Third, any over-identification assumptions implied by the economic theory are easily tested. Finally, the GMM estimation procedure is computationally simpler than the LP, OP, and ACF two-step estimators[11].

3.5 Empirical Results

Our empirical results are presented in two steps. First, we present the estimates of the linear interaction model. We find evidence that the DTF is a significant determinant of the impact of FDI on the productivity growth of Chilean firms. Second, we provide

[10] This estimator is often referred as Wooldridge-Levinsohn-Petrin (WLP) estimator. See for example Petrin *et al.* (2011).

[11] Additional details about Wooldridge's (2009) estimator are provided in the Appendix D.

the results of our test for the presence of non-linear spillovers from foreign firms to domestic firms. Our estimates show that there is an inverted U-shaped relationship between DTF and the spillovers from FDI, supporting our hypothesis of non-linear effects.

3.5.1 Linear interaction model

Table 3.1 summarizes the main results from the linear interaction model. In all the specifications, —other things being equal— firms with larger DTFs are found to experience faster rates of productivity growth. The parameter for the DTF —approximately 1.26— is always positive and significant at one per cent level. This result suggests that domestic firms tend to converge to the technological frontier. This conclusion is in line with the results reported by Girma (2005) and Griffith *et al.* (2002) for the UK, and by Alvarez & Crespi (2007) for Chile.

As expected, the Herfindahl concentration index has a negative effect on productivity growth, however the coefficient is not statistically significant.

Focusing on the role played by the industry-level FDI variables, we have that the parameter measuring the direct effect of FDI on productivity is not statistically different from zero in any specification, i.e. when FDI is measured as the participation of foreign firms in total sectoral output, employment or capital. Nevertheless, when FDI is interacted with the DTF, the parameter is negative and statistically significant —at the 5 per cent level— when FDI is measured as the participation of multinationals in employment. Therefore, the higher is the DTF, the lower is the impact of FDI on the productivity growth of domestic firms.

Table 3.1: Linear Interaction Model: Fixed Effects Regressions Results

	(1) dln(TFP)	(2) dln(TFP)	(3) dln(TFP)
Herf_{t-1}	-0.1717	-0.1712	-0.1818
	(0.2047)	(0.1988)	(0.2015)
DTF_{t-1}	1.2625***	1.2750***	1.2605***
	(0.1371)	(0.1360)	(0.1376)
FDI^{Q}_{t-1}	0.05290		
	(0.1727)		
FDI^{Q}_{t-1}*DTF_{t-1}	-0.2244		
	(0.1850)		
FDI^{L}_{t-1}		0.2474	
		(0.2734)	
FDI^{L}_{t-1}*DTF_{t-1}		-0.6993**	
		(0.3146)	
FDI^{K}_{t-1}			-0.01192
			(0.1694)
FDI^{K}_{t-1}*DTF_{t-1}			-0.1838
			(0.1830)
Observations	33,497	33,497	33,497

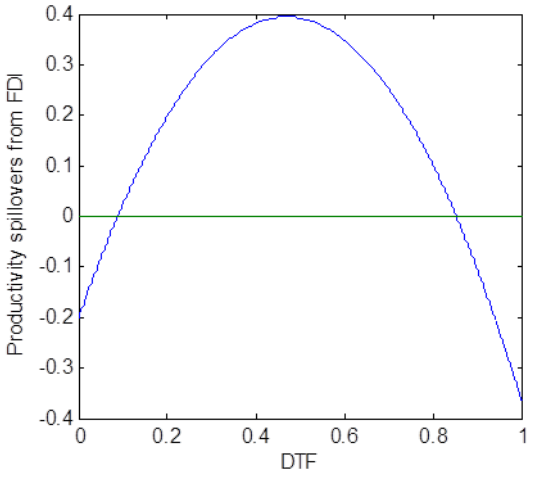
Standard errors (in parentheses) have been corrected for clustering for each industry in each year.
All regressions include firm and year fixed effects.
*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

3.5.2 Quadratic interaction model

Table 3.2 presents the results of the estimation of the quadratic interaction model, using fixed effects regressions. Overall, our estimations produce statistically significant coefficients on all FDI variables, when FDI is interacted with the DTF.

In addition, the estimates from the quadratic interaction model show that the linear model may be ignoring some important non-linearities. As reported in Table 3.2, the quadratic interaction term is always negative and statistically significant, indicating that there is an inverted U-shaped relationship between DTF and the spillovers from FDI, i.e. δ. Figure 3.1 illustrates this relationship when FDI is measured as the participation of foreign firms in sectoral employment.

Figure 3.1: Relationship between Spillovers from FDI and DTF



An inverted U-shaped relationship (concave curve) between the DTF and FDI spillovers means that there are two levels of the DTF at which the productivity spillovers from FDI are equal to zero (let us say DTF_{low} and DTF_{high}). Firms with DTF below DTF_{low} or above DTF_{high} are not able to benefit from the spillovers generated by multinationals. Firms need a minimum level of TFP in order to incorporate

Table 3.2: Quadratic Interaction Model: Fixed Effects Regressions Results

	(1) dln(TFP)	(2) dln(TFP)	(3) dln(TFP)
Herf_{t-1}	-0.2464	-0.2561	-0.2674
	(0.1955)	(0.1905)	(0.1940)
DTF_{t-1}	-2.0787***	-2.0739***	-2.0730***
	(0.3325)	(0.3227)	(0.3259)
$\text{DTF}^2{}_{t-1}$	2.5629***	2.5676***	2.5562***
	(0.3156)	(0.3065)	(0.3099)
FDI^Q_{t-1}	-0.3237		
	(0.2522)		
FDI^Q_{t-1}*DTF_{t-1}	1.7104**		
	(0.8058)		
FDI^Q_{t-1}*$\text{DTF}^2{}_{t-1}$	-1.7202***		
	(0.6351)		
FDI^L_{t-1}		-0.4660	
		(0.3796)	
FDI^L_{t-1}*DTF_{t-1}		2.7488**	
		(1.1617)	
FDI^L_{t-1}*$\text{DTF}^2{}_{t-1}$		-2.9913***	
		(0.9548)	
FDI^K_{t-1}			-0.4502*
			(0.2488)
FDI^K_{t-1}*DTF_{t-1}			2.0005**
			(0.8695)
FDI^K_{t-1}*$\text{DTF}^2{}_{t-1}$			-1.9077***
			(0.6967)
Observations	33,497	33,497	33,497

Standard errors (in parentheses) have been corrected for clustering for each industry in each year.
All regressions include firm and year fixed effects.
*,**, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

the new knowledge transferred by foreign firms, that is, firms with $DTF > DTF_{high}$ are not able to benefit from foreign presence. However, once domestic firms have increased their productivity to a level closer to the technological leader ($DTF < DTF_{low}$), they no longer benefit from additional increases in FDI. Therefore, only firms for which $DTF_{low} < DTF < DTF_{high}$, benefit from FDI via productivity spillovers. This conclusion is in line with the findings of Girma (2005) and Girma & Wakelin (2007) for the UK manufacturing sector.

Table 3.3 includes the values of DTF_{low} and DTF_{high} for each of the specifications used. For instance, when FDI is measured as the participation of foreign firms in sectoral output, domestic firms with a DTF above 0.74 or below 0.25 do not benefit from FDI. Only firms with a DTF between these two thresholds raise their productivity growth rate as a consequence of an increase in FDI. The productivity effect of FDI begins to decline in size once the DTF reaches its turning point of 0.50.

Table 3.3: Critical Values of the DTF

Measure of FDI	DTF_{low}	DTF_{high}	Turning point
Participation in sectoral output	0.254	0.740	0.506
Participation in sectoral labour	0.087	0.8519	0.459
Participation in sectoral capital	0.1170	0.8411	0.524

3.6 Conclusions

In this chapter we analysed the impact of FDI on the productivity of domestic manufacturing firms in Chile. The analysis specifically addresses whether the presence of foreign firms in the same industry as domestic firms leads to (horizontal) productivity spillovers, and the extent to which these spillovers are related to the DTF of the local firms. Our results suggest that the DTF is an important mediating factor for productivity spillovers from FDI. Overall, FDI has positively affected Chilean

manufacturing firms, but those spillovers have not been equally distributed among the firms. Actually, we find evidence that spillovers from FDI exhibit an inverted U-shaped relationship with respect to the DTFs of domestic firms. That is, domestic firms need a minimum level of productivity in order to benefit from FDI. However, as they approach the technological frontier, the spillovers from FDI start to diminish, and eventually become negative.

This conclusion has important policy implications. Since the effects of FDI on productivity differ among firms, policies that encourage inward FDI without considering such differences may fail to enhance the productivity growth of domestic firms.

Appendix C

Complementary Figures

Figure C.1: Chile: Accumulated Net FDI Inflows (Millions of Nominal USD)

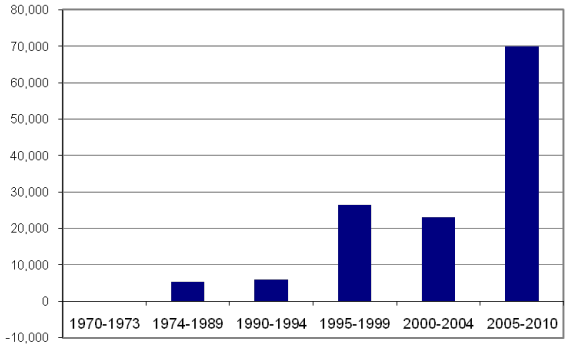


Figure C.2: Chile: Net FDI Inflows (Percentage of GDP)

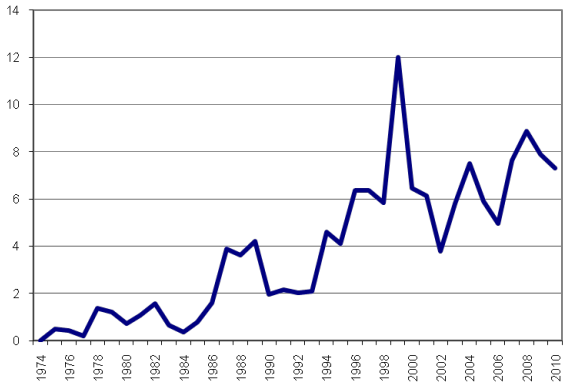
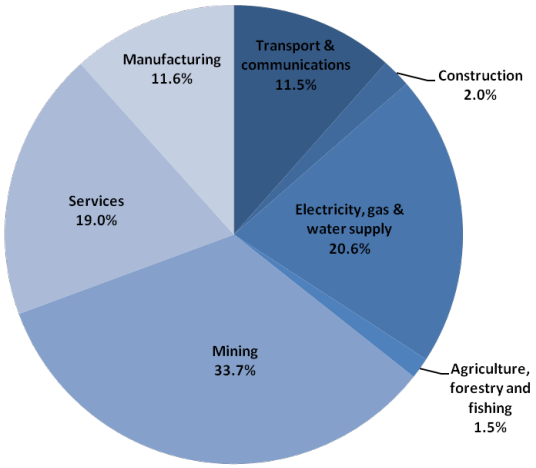


Figure C.3: Chile: Gross FDI Inflows by Sector (Percentage of Accumulated Inflows between 1974 and 2013)



Appendix D

An unbiased and efficient measure of productivity: Wooldridge (2009)

Assume a standard Cobb-Douglas production function for firm i at time t:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + v_{it} + e_{it} \tag{D.1}$$

where y_{it} is the firm's output, l_{it} is employment, and k_{it} is the capital stock, all in logarithmic form. For simplicity, y_{it} represents the value-added, but similar analysis holds when considering gross output, in which case equation D.1 would also include intermediate materials. v_{it} is productivity that is observed by the firm, but unobserved by the econometrician, and e_{it} is an unexpected productivity shock that is unobserved by both the firm and the econometrician (or a random error term). Because v_{it} is observable by the firm, it affects the firm's input choices; namely, it is a state variable. Inconsistent estimators will be obtained when the estimation ignores the correlation between this error term and the input choices.

The main implication of Olley and Pakes (OP, 1996) and Levinsohn and Petrin (LP, 2003) is that for some function $f(\centerdot, \centerdot)$,

$$m_{it} = f(k_{it}, v_{it}),\ t = 1, 2, \ldots, T \tag{D.2}$$

where m_{it} is a vector of proxy variables (investment in the OP and intermediate materials in the LP approach). Under certain assumptions $f(\centerdot, \centerdot)$ can be inverted to

obtain

$$v_{it} = g(k_{it}, m_{it})\, t = 1, 2, \ldots, T \tag{D.3}$$

Assuming that $E(e_{it}|k_{it}, m_{it}) = 0$, and substituting from D.3 for v_{it}, D.1 can be written as:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + g(k_{it}, m_{it}) + e_{it},\ t = 1, 2, \ldots, T \tag{D.4}$$

The parameters β_l and β_k will not be separately identified, the former due to collinearity between labour and productivity, as demonstrated by Ackerberg *et al.* (2015), and the latter due to the inclusion of k_{it} in $g(\centerdot, \centerdot)$.

As a solution, Wooldridge (2009) proposes to impose the following condition:

$$E\left[e_{it}|l_{it}, k_{it}, m_{it}, l_{it-1}, k_{it-1}, m_{it-1}, \ldots, l_{i1}, k_{i1}, m_{i1}\right] = 0,\ t = 1, \ldots, T \tag{D.5}$$

and also to restrict the dynamics in the productivity process, such that:

$$E\left[v_{it}|k_{it}, l_{it-1}, k_{it-1}, m_{it-1}, \ldots\right] = E\left[v_{it}|v_{it-1}\right] \equiv f\left[g\left((k_{it-1}, m_{it-1})\right)\right] \tag{D.6}$$

Therefore,

$$v_{it} = f(v_{it-1}) + a_{it}\ with\ E\left[a_{it}|k_{it}, l_{it-1}, k_{it-1}, m_{it-1}, \ldots\right] = 0 \tag{D.7}$$

which allows labour demand l_{it} and intermediate inputs m_{it} to be correlated with the productivity innovations a_{it}. However, k_{it}, past (l_{it}, k_{it}, m_{it}), and functions of these are uncorrelated with a_{it}.

Plugging D.7 into the production function D.1 provides us with a second equation which can be used to identify the two parameters of interest, β_l andβ_k:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + f\left[g(k_{it-1}, m_{it-1})\right] + a_{it} + e_{it} \tag{D.8}$$

Now, we have two equations that identify (β_l, β_k), namely D.4 and D.8.

The orthogonality condition for equation D.4 is given by:

$$E\left[e_{it}|l_{it}, k_{it}, m_{it}, l_{it-1}, k_{it-1}, m_{it-1,} \ldots, l_{i1}, k_{i1}, m_i 1\right] = 0,\ t = 1, 2, \ldots, T \tag{D.9}$$

which implies that l_{it}, k_{it} and m_{it} act as their own instruments for equation D.4, and there are many other instruments obtained from lags of these three variables.

For equation D.8 the orthogonality condition is given by:

$$E\left[u_{it}|k_{it}, l_{it-1}, k_{it-1}, m_{it-1}, \ldots, l_{i1}, k_{i1}, m_{i1}\right] = 0,\ t = 2, \ldots, T \tag{D.10}$$

therefore in equation D.8 l_{it} is endogenous, but k_{it}, k_{it-1}, and m_{it-1} act as their own instruments. We can use l_{it-1} and other lags of everything as instruments for l_{it}.

The unknown functions $g(\centerdot, \centerdot)$ and $f(\centerdot, \centerdot)$ are approximated by third-degree polynomials.Once we have consistent estimators for β_l and β_k, through GMM estimation, we can obtain productivity as a residual:

$$\hat{v}_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} \tag{D.11}$$

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