The Impact of Globalisation on Firm Performance and Wages in an Emerging Economy Context

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PhD Thesis

Statement of Own Work

I, Caroline Paunov, confirm that the work presented in this thesis is my own. I am the single author of all chapters with the exception of Chapters 2 and 4. These chapters were written jointly with Ana Margarida Fernandes. My contribution to those chapters consisted in working jointly with Ana Margarida Fernandes on the elaboration of the topics, the assessment of the literature, the empirical work and final drafting.

Where information has been derived from other sources, I confirm that this has been indicated in the thesis. The material contained in this thesis has not previously been submitted for a degree at University of London or any other university.

Caroline Paunov

Abstract

We analyze the impacts of globalisation on firm performance and firms' relative wage payments in an emerging economy context. Using a rich set of manufacturing firm census data for Chile, we study four specific empirical issues, (1) the impacts of foreign direct investment in services on firm total factor productivity (TFP) growth, (2) the heterogeneous effects of import competition on firm TFP, (3) the effect of import competition on firm product upgrading and, (4) the question whether trade had an impact on decreasing relative manufacturing wages. The analysis exploits the panel nature of the dataset, an exogenous measure of import competition – transport costs – and, most importantly, the availability of detailed information on firms' products and their prices to investigate these questions rigorously. Specifically, we use the latter information to compute improved TFP measures, analyze product upgrading with a direct quantitative measure - unit prices of firms' products – and assess the impact of price changes on wages not only by industry but equally at the firm level. We find an overall positive impact of import competition on firm performance – both on TFP improvements and product innovation. Moreover, results show a positive and significant effect of foreign direct investment in services on TFP growth. However, our results also suggest that globalisation alone may not be sufficient a tool for development. While import competition has a strongly positive impact on product upgrading, we do not find that competition from developed countries stimulates such innovation. The gap between both types of economies may be too large. Also, the overall positive impact of import competition on firm TFP is lower for smaller firms; they will not benefit to the same extent as larger firms. Finally, we find that price effects of trade do not explain the observed reduction in manufacturing wage inequality.

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Chapter 1: Introduction and Summary

1. Summary

Over the last decades many emerging countries have opened their economies to foreigners as trading partners as well as for direct investment. While many factors have contributed to these developments; the failure of previous protective policies in the case of many Latin American economies and the belief that competition as well as foreign know-how may facilitate development have certainly played a role. We analyze the impacts of globalisation on firm productivity, their potential for innovation and its outcomes for the firms' employees in an emerging economy context. Our objective is to understand the opportunities and limitations of globalisation as an option for development. In order to explore these questions we use very rich Census data on firms in Chile which are collected by the Chilean Statistical Office and have, for their quality, been widely used in empirical research. We formulate four specific empirical questions, the impacts of services FDI on manufacturing firm total factor productivity (TFP) growth, the heterogeneous impacts of import competition on manufacturing firm TFP, the effect of import competition on firm product upgrading and, finally, the question whether trade had an impact on decreasing manufacturing sector wage inequality in Chile.

Overall, our evidence highlights positive impacts of globalisation on Chilean firm performance, both in terms of total factor productivity improvements and product quality upgrading. We find, however, some limitations to the positive effects of globalisation. First, while import competition has a strongly positive impact on product upgrading, it seems mainly competition from other emerging economies that stimulates such innovation. Competition from developed countries does not have a similar effect.

Second, we find a general positive effect of import competition on firm productivity – it is a lot stronger for larger firms though and this potentially suggests that small firms face hindrances to improve processes to become more efficient. They also seem to suffer stronger productivity losses due to Chinese import competition. We interpret the latter evidence jointly with our evidence of product quality upgrading and product adoption as production adjustment costs.

The policy implications of our findings point to the importance of globalisation for firm development and at the same time suggest that globalisation may not by itself be sufficient. To be more precise, import competition may be insufficient to enable quality upgrading where the "technology gap" between foreign competitors and local producers is high. Other policy tools may be necessary for more radical innovations. Another concern that arises is that small firms benefit less from foreign competition and suffer more from adjustment costs from Chinese competition. This suggests possibly that they do not have the same possibilities bigger firms have to respond to the challenge of foreign competition. Policies offering support to "disadvantaged" firms may possibly be interesting to allow spreading the benefits of globalisation more widely among firms.

2. Methodological Considerations and Contributions

A measure of central importance to our analysis is TFP as a measure of firm performance; they are the main measure of firm performance and used in all thematic chapters with the notable exception of Chapter 4 where firm product prices are used to evaluate innovation performance. Several introductory comments are well placed in the introduction to explain why different measures are used in the different thematic chapters. First of all, a central input required to obtain firm TFP measures is to obtain real firm output. This is usually obtained using nominal sales deflated by an industry-level price deflator as firm price deflators are not available. In Chapter 3 we discuss shortcomings of these *traditional* TFP estimates and obtain *improved* measures in that we use firm-level output deflators to obtain real output measures for our production function estimates. This procedure avoids several biases that arise if industry-level deflators are used. Chapter 3 explains those shortcomings in further detail. We use these improved measures in both Chapters 3 and 5. Since we do not have firm-level price data before 1996, we can only use *traditional* TFP estimates in Chapter 2 where our analysis spans the 1992 – 2004 period.

Second, the other important question is how firm production functions are specified to obtain TFP estimates. Two methods have been particularly popular in the applied empirical literature, the index method and semi-parametric estimation techniques originally proposed by Olley and Pakes (1996). Both Chapters 2 and 3 select the method proposed by Levinsohn and Petrin (2003), a modification of Olley and Pakes (1996), as their method allows including most firms in the production function estimates rather than only those with non-zero investments as is the case for Olley and Pakes (1996). However, the recent contribution by Ackerberg et al. (2006) puts that specific estimation technique in question. This topic is discussed in further detail in Chapter 2.

Recognizing the validity of this recent critique, we estimate our main specification in Chapter 2 using the method proposed by Ackerberg et al. (2006). We find that results are robust; this suggests that in practice, the estimation technique is potentially not affecting the main conclusions. For future research the critique certainly suggests using the method proposed by Ackerberg et al. (2006). As for the index method, it is used to confirm results in Chapter 2 suggesting that for our findings, the estimation technique is not material. The index method is used as the main estimation technique in Chapter 5 because in that chapter we seek to establish a comparative analysis of results produced by Haskel and Slaughter (2001) to compare performance of the Chilean sector. This is also facilitated since we do not find substantial differences across estimation techniques in Chapter 2.

As to our methodological contributions, we are interested in whether *improved* TFP measures lead to different conclusions when applied to the discussion of specific questions. We do the experiment looking at the question of the impacts of import competition on productivity. Moreover, we explore the use of an alternative measure, product unit prices, to investigate incremental product innovations. The major advantage is that we avoid using problematic qualitative variables for less radical innovations which are the most prevalent type of innovation measure in emerging economies. Furthermore, we explore the use of firm-specific weights of services uses to analyzse the impact of vertical FDI linkages and investigate whether there are differences caused by aggregation when analyzing mandated wage equations at the firm rather than the industry level.

3. Data

Turning to the data, the main dataset used is the Encuesta Nacional Industrial Annual (ENIA), which is the annual manufacturing census of Chilean plants covering all plants with more than 10 employees. The dataset is an unbalanced panel reflecting plant entry and exit that has been collected annually since 1979 and used widely in a large number of analyses. We select the 1992 – 2004 period for the analysis of the impacts of FDI since it covers the period where significant investments took place, and otherwise work with the 1996 – 2003 sample. Table 1 shows the number of plants across all years analyzed in our sample and their distribution across 3-digit ISIC (revision 2) industries.

A second central dataset we use intensively provides information on the products produced by Chilean plants from 1996 to 2003. The products dataset includes information for each plant and year on the physical quantity sold and the sales value of each of 2,018 products at the 7-digit ISIC level (revision 2). Complementary datasets for our analysis are FDI inflow and outflow data for different services sectors from the Chilean Foreign Investment Committee and detailed information on freight costs of Chilean imports for each 8-digit Harmonized System (HS) code, exporting country, and year from 1997 to 2003 provided by the Latin American Integration Association (ALADI).

4. Regulatory Changes and Macroeconomic Trends in Chile

It is useful to interpret the micro evidence in light of the macroeconomic context the Chilean economy faced over the past decade to situate the micro findings in the macro context. Starting with overall growth performance, Chile has been very successful over the past two decades achieving an increase in per capita income relative to that of the United States from 18% in 1986 to 31% in 2007 (OECD, 2010). The past decades have been marked by an overall very successful growth performance. Figure 1 shows growth rates for the Chilean economy illustrating high growth performance over the 1990s and good performance from 2000 up to the current world financial crisis in 2008. The downturn in 1999 was due to spillover effects of the Asian crisis of 1998. As shown in Figure 2 the growth of the manufacturing sector largely followed the overall growth rate of the economy. This shows that there were no major shifts reducing or increasing the share of the manufacturing sector in overall GDP. As for overall employment dynamics, there has been a constant increase in employment over the past two decades;

the increase was by more than 2.5 million between 1987 and 2008. Downturns to economic growth have only had mild effects on employment.

Obviously, various factors contributed including the adoption of a good macroeconomic policy regime. One explanation is specifically important in our context – the liberalization of foreign trade and foreign direct investment. Results were a flat 6% multilateral tariff across all imports in place since the 1980s reforms, the removal of barriers to foreign direct investment. The efforts at strengthening openness have been intensified with the signature of several free trade agreements with key trading partners. This effectively means that the effects we study are impacts of trade liberalization subsequently to its initial implementation and initial effects.

In terms of trends, there has been a significant increase in foreign direct investment (FDI) starting in the 1990s - Figure 2. Most of the investment was investment in business services as is explained in further detail in Chapter 2. Investments remained significant up to 2006 reflecting that Chile has become an attractive source for foreign direct investment. For Chilean firms this means that both potential learning opportunities from foreign firms and competition effects may have changed significantly. This provides a strong motivation to study the effects of FDI on firms, the topic of Chapter 2. Moreover, as shown in Figure 5 imports (as well as exports) increased significantly subsequently to trade liberalization. This is also the case for 1992 – 2004 which is the period we study here. The question we effectively analyze here is whether this increase in imports shown here did have impacts on manufacturing firm performance.

In light of our discussion on wage inequality it is equally important to discuss labour market reforms in Chile. The military regime in place in Chile from 1973 until 1990 implemented a series of reforms that shape the current labour market regulations up to the present as the subsequent democratic governments did not reverse the general labour market regulatory framework. Edwards and Cox Edwards (2000) summarise those reforms into three major types: First, efforts were made to increase labour market "flexibility" by reducing the maximum length of serverance pay and imposing a ceiling on the amount paid. Second, collective bargaining was modified reducing the centralized power of unions as wage bargaining was decentralized to the level of the firm. Third, payroll taxes were reduced. A main characteristic of the democratic governments in place since 1990 up to the present is, however, a stronger concern for social policies, the most important being the increase in the limit to severance payment from 5 to 11 months in 1991 (Lima and Paredes, 2004). Subsequently to that date there was no significant labour market reform. However, due to the effects of the Asian crisis a previously set minimum wage increase (based on expectations of continued high growth rates) led to an unintended increase of almost 30% between 1998 and 2001 (Lima and Paredes, 2004). To the best of our knowledge there is only one study that looks at the impacts of this change in minimum wages, their main finding is that this rise in minimum wages increased the share of workers receiving minimum wages or less pay and coincided with fewer workers having formal employment contracts (Infante et al., 2003). They do not study the impacts on wage inequality. The latter policy change is potentially significant for our analysis of wage inequality.

5. Review by Chapter

We now review our analysis chapter by chapter. Chapter 2 is entitled "Foreign Direct Investment in Services and Manufacturing Productivity Growth: Evidence for Chile." During the 1990s, foreign direct investment in producer service sectors in Latin

America was massive. Such investment may increase the quality of services, reduce their cost, and offer opportunities for knowledge spillovers to downstream users of the services. This chapter examines the effects of foreign direct investment in services on manufacturing productivity growth in Chile between 1992 and 2004. We estimate an extended production function where plant TFP depends on a weighted measure of foreign direct investment in services. The novelty of the approach is that we are able to assess the intensity of usage of various types of services at the plant level and use that information in the estimation of the importance of foreign direct investment in those services for plants. The econometric results show a positive and significant effect of foreign direct investment in services on productivity growth of Chilean manufacturing plants which is robust to a multitude of tests. The economic impact of the estimates is that forward linkages from foreign direct investment in services account for almost 4 percent of the observed increase in Chilean manufacturing productivity growth during the sample period. This evidence therefore suggests that reducing the barriers restricting foreign direct investment in services in many developing economies may help accelerate productivity growth in their manufacturing sectors.

Chapter 3 is entitled "Improved TFP Estimates and their Responsiveness to Assessing the Effects of Trade Competition." Many studies find a positive effect of import competition on firm total factor productivity (TFP) estimates. In this chapter we contribute to the literature in two ways. First, we make use of our data on Chilean firms and their products to compute improved TFP estimates and analyze whether these provide the same answer. Second, we use transport costs as a measure of import competition which we argue avoids the problems of endogeneity. Our results suggest that import competition has a positive effect across all TFP measures. Better performing firms tend to benefit more. Import competition from China has a negative effect due to temporary efficiency losses as firms adjust production to face competition.

Chapter 4 is entitled "Does Tougher Import Competition Lead to Product Upgrading?" Over the last two decades globalization, and more specifically the increased exposure to competition from low-price producers in China and India, has created a new economic environment for other emerging economies. It is widely conjectured that the most advantageous way for manufacturing firms in those economies to position themselves in domestic and international markets is to offer upgraded and differentiated rather than "mundane" labor-intensive products. This chapter investigates whether increased competitive pressure from imports forces firms to improve the quality of their products. The econometric analysis relies on a rich dataset of Chilean manufacturing plants and their products. Product quality is measured with unit values (average prices) and industry-level transport costs are used as an exogenous measure of import competition. We find a positive and robust effect of import competition on product quality. This effect is found to be particularly strong for non-exporting plants. The results also show that increased import competition from less advanced economies is the major cause for the positive impact on quality upgrading. The overall evidence points to the benefits of trade openness for product innovation but demonstrates at the same time that competitive pressures alone will not enable local plants to catch up with leading world producers.

Chapter 5 is entitled "Technology versus Trade: What explains relative wage changes in Chile?" This chapter analyses the effects of trade and technological change on the decrease in wage inequality in the Chilean manufacturing sector for the 1996 - 2003 period. We establish the impact of trade by means of regressing product price changes on production cost shares of skilled and unskilled labour as well as capital. We do the same analysis for technological change which is measured by total factor productivity growth. A novelty of our study is that we conduct the analysis both at firm and industry levels. We find that technological change rather than trade explains the decrease in relative wages.

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Chapter 1: Table and Figures

Table 1: Sample Composition of the ENIA

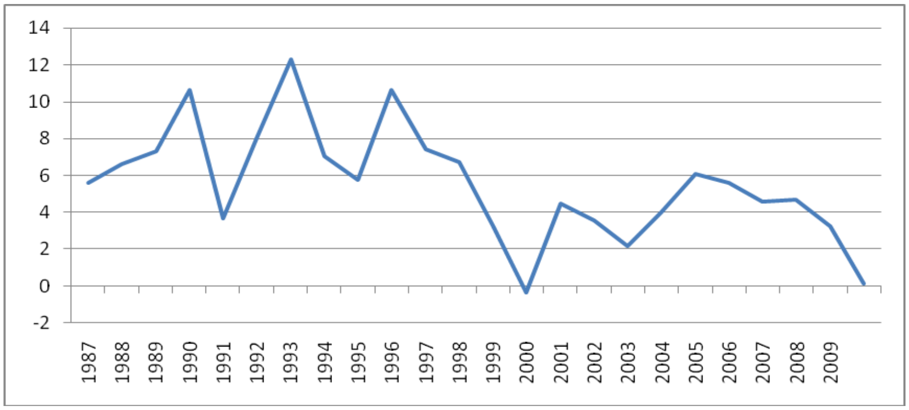
Panel A: Across Years

Year	Number of Plants	Share in Total
1992	4394	7.71
1993	4497	7.89
1994	4586	8.04
1995	4583	8.04
1996	4872	8.54
1997	4670	8.19
1998	4252	7.46
1999	3875	6.80
2000	3994	7.00
2001	4038	7.08
2002	4366	7.66
2003	4332	7.60
2004	4566	8.01
Total	57025	100.00

Panel B: Across Industries

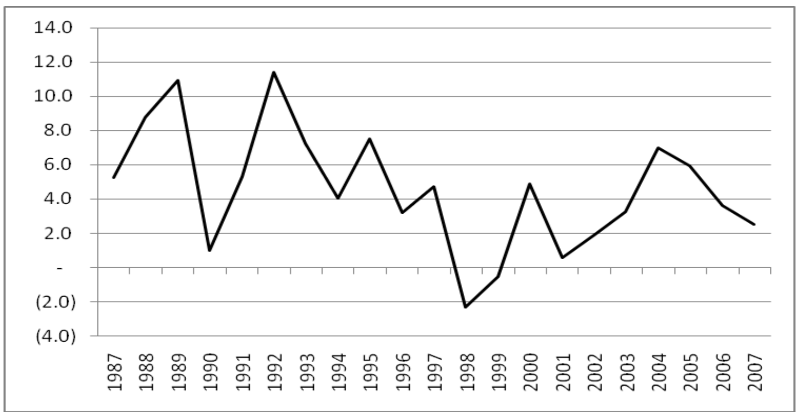
ISIC		Number of Observations	Share in Total
311	Food Products	15959	27.99
312	Other Food Products	837	1.47
313	Beverages	1131	1.98
314	Tobacco	8	0.01
321	Textiles	3774	6.62
322	Apparel	3293	5.77
323	Leather Products	494	0.87
324	Footwear	1604	2.81
331	Wood Products	3967	6.96
332	Furniture	1761	3.09
341	Paper	1052	1.84
342	Printing	2604	4.57
351	Industrial Chemicals	723	1.27
352	Other Chemicals	2149	3.77
353	Petroleum Refineries	52	0.09
354	Petroleum and Coal Products	202	0.35
355	Rubber Products	693	1.22
356	Plastics	3161	5.54
361	Ceramics	186	0.33
362	Glass	277	0.49
369	Nonmetallic Minerals	1898	3.33
371	Iron and Steel	457	0.80
372	Non-ferrous Metals	444	0.78
381	Metal Products	5365	9.41
382	Nonelectrical Machinery	2021	3.54
383	Electrical Machinery	805	1.41
384	Transport Equipment	1102	1.93
385	Professional Equipment	295	0.52
390	Other Manufacturing	711	1.25
Total		57025	100.00

Figure 1: GDP Growth in Chile, 1987 - 2009



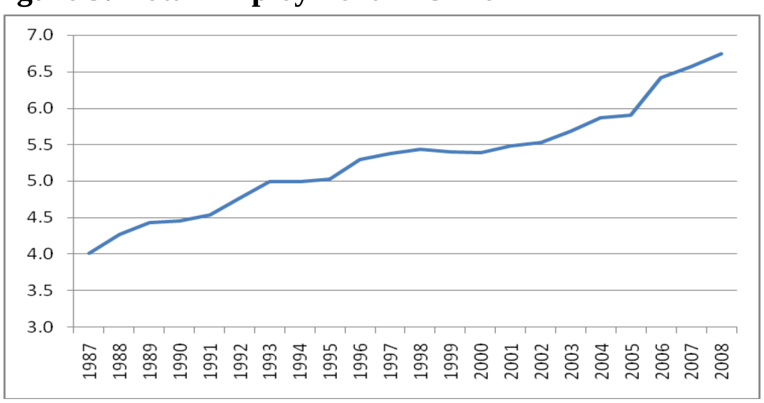
Note: The graph reports annual percentage growth rates of GDP.
Source: IMF World Economic Outlook Database

Figure 2: Manufacturing Sector Growth in Value-Added in Chile, 1987 - 2007



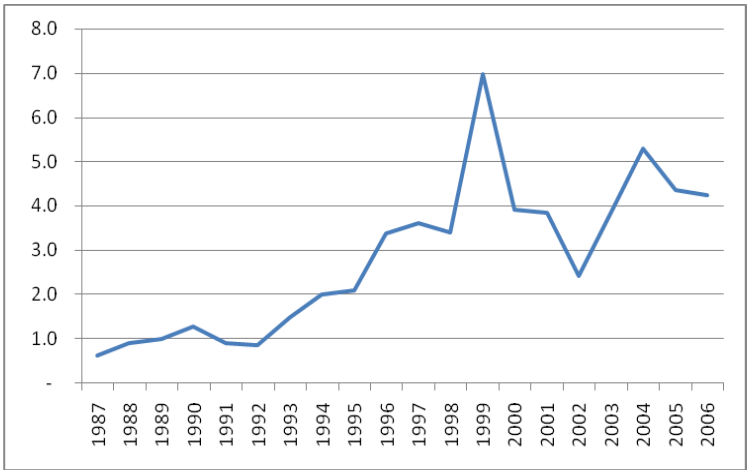
Note: The graph reports annual percentage growth rates of the value-added of the manufacturing sector.
Source: National Accounts Estimates of Main Aggregates, United Nations Statistics Division

Figure 3: Total Employment in Chile



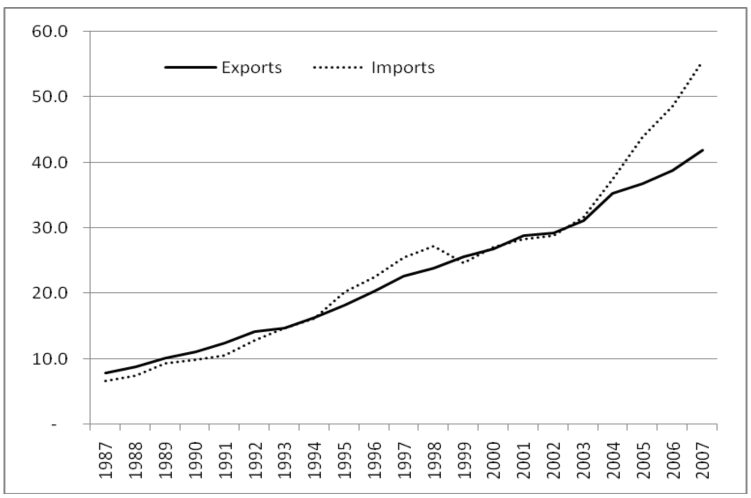
Note: The graph shows employment in million.
Source: Labor Statistics Database, International Labor Organization

Figure 4: Foreign Direct Investment Flows to Chile, 1987 – 2006



Note: The graph shows foreign direct investment flows to Chile measued in constant 1990 billion USD.
Source: UNCTAD Handbook of Statistics

Figure 5: Chilean Exports and Imports, 1987- 2007



Note: The graph shows Chilean exports and imports from Chile in constant 1990 billion USD
Source: National Accounts Estimates of Main Aggregates, United Nations Statistics Division

Chapter 2: Foreign Direct Investment in Services and Manufacturing Productivity Growth: Evidence for Chile*

(Co-authored with Ana M. Fernandes, The World Bank)

Abstract

This chapter examines the effects of substantial foreign direct investment (FDI) inflows in producer services on the total factor productivity (TFP) growth of Chilean manufacturing firms. The novelty of our approach is the reliance on a service FDI measure where plant-level time-varying measures of the intensity of service usage are used as weights for FDI penetration in service sectors. We find a positive and significant effect of FDI in services on plant TFP growth that is robust to a variety of tests. These effects are neither driven by any specific industry nor are they restricted to certain types of plants only.

Keywords: Total Factor Productivity Growth, Services Liberalization, Foreign Direct Investment, Chile.

JEL Classification codes: D24, L8, L9, F21, F23.

* This chapter is based on Fernandes, A. and C. Paunov (2008), Foreign Direct Investment in Services and Manufacturing Productivity Growth: Evidence for Chile, World Bank Policy Research Working Paper No. 4730.

1. Introduction

Foreign direct investment (FDI) inflows into the service sector experienced a boom during the 1990s. By 2002, services accounted for 60% of the world stock of FDI, a four-fold increase since 1990 (UNCTAD, 2004). The main recipients of FDI have been profit-seeking producer services which range from network-intensive services such as electricity, telecommunications, and transport to finance and business services. These services are characterized by the facilitating and intermediating role which they play for downstream user firms (Francois, 1990). Thus, better performing producer service sectors would strengthen a country's business environment. A potentially powerful means to achieve such improvements is FDI which can lead to increases in the quality and variety of services available and lower their cost. Manufacturing firms may also benefit from their interaction with foreign services suppliers through spillovers of management, organizational, marketing, or technological knowledge.[1]

Despite the relevance of this topic, the effects of vertical linkages resulting from the openness of producer services to FDI on manufacturing firms have not been widely documented (Hoekman, 2006). This chapter attempts to fill this gap by addressing the following question: did the increased penetration of FDI into producer service sectors in Chile benefit total factor productivity (TFP) growth of manufacturing plants between 1992 and 2004? Chile is an interesting economy to study as its service sector received large FDI inflows during the 1990s. Our empirical framework obtains plant TFP estimates and the corresponding TFP growth following the Levinsohn and Petrin (2003) method which corrects for the endogeneity of input choices - including the choice of service inputs - with respect to productivity. Then our main specification consists of a

[1] See Markusen (1989) and Rivera-Batiz and Rivera-Batiz (1992) for a theoretical discussion of the benefits from FDI in services.

regression of plant TFP growth on a service FDI linkage measure. The following intuitive argument is made in defining that measure. If FDI in services affects TFP growth, then one would expect plants that use services more intensively to benefit more. Thus, our service FDI linkage measure is defined as service FDI penetration weighted by the intensity of service usage at the plant level. To identify a causal effect of service FDI on plant TFP growth, our regressions include the two-period lagged service FDI linkage measure, control for the potential endogeneity of services usage and for unobserved fixed differences in TFP growth across plants, for observable plant characteristics, for industry-level and region-level time-varying heterogeneity.

We find evidence of a positive and significant effect of service FDI on the TFP growth of Chilean manufacturing plants that use those services more intensively. Our results are robust to the use of alternative measures of plant TFP growth based on production function estimation following Olley and Pakes (1996) or Ackerberg et al. (2006), and to a growth accounting index measure of TFP growth. Variations in the definition of the service FDI penetration and the plant-level weights, and other robustness checks confirm our evidence. By exploiting regional differences in FDI, we demonstrate that the estimated effect of the service FDI variable is capturing the benefits from FDI rather than those from contemporaneous regulatory reforms in service sectors. Interestingly, we also show that our estimated effects are not driven by any specific industry and that there is only weak evidence that those effects are stronger for plants in differentiated product industries. Finally we find no evidence of differential effects of FDI in services on TFP growth across small and large plants and across domestic and foreign-owned plants.

Our preferred estimate suggests that the average increase in the service FDI linkage between 1992 and 2004 added 1.1 percentage points to annual plant TFP growth in Chile, all else constant. The corresponding economic impact is that forward linkages from service FDI accounted for almost 4% of the observed increase in manufacturing users' TFP growth in Chile during the sample period. This economic impact is quite meaningful in light of the finding by Haskel et al. (2007) that spillovers from manufacturing FDI explain a roughly similar share of manufacturing TFP growth in the U.K. during the 1973-1992 period. Since a large fraction of service FDI inflows in Chile consisted in the acquisition of incumbent firms - many of which were privately-owned since the late 1980s - our impact is likely to be an underestimate of the potential impacts in countries where FDI inflows are directed at the privatization of service providers or at the creation of new service providers. The positive effects of service FDI on TFP growth of manufacturing plants may capture to some extent an unmeasured decline in quality-adjusted services prices but also the spillover of managerial and organizational knowledge from service providers to manufacturing users. Notwithstanding, there are several alternative interpretations that could explain our results as will be discussed in the conclusions.

The microeconomic evidence provided by our study contributes to the emerging literature on the impact of services liberalization on growth and on the performance of services users. At the macro level, Mattoo et al. (2006) and Eschenbach and Hoekman (2006) show that countries with liberalized service sectors grow faster, once all standard growth correlates are controlled for. Based on computable general equilibrium models, Konan and Maskus (2006) and Jensen et al. (2007) argue that business services liberalization could bring large GDP gains to Tunisia and Russia, respectively.[2] The main mechanism for these gains is the increase in the number of services available for manufacturing users as a result of FDI.[3] At the industry level, Francois and Woerz (2007) show that the increased openness of business services through exports and FDI has strong positive effects on exports, value added, and employment of manufacturing industries in the OECD while Fernandes (2007) estimates positive and significant effects of liberalization of finance and infrastructure on labor productivity of downstream manufacturing industries in Eastern European countries. At the firm-level, Arnold et al. (2007a) show significant positive effects of services liberalization in the Czech Republic on manufacturing firms' TFP while Arnold et al. (2007b) find significant positive effects of banking, telecommunications, and transport reforms on Indian manufacturing firms' TFP. Finally, Javorcik and Li (2007) estimate a positive effect of FDI in Romania's retail sector on the TFP of manufacturing suppliers to that sector. By exploiting plant heterogeneity in service usage, our study differs from these studies which capture the dependence of manufacturing firms on services using industry-level coefficients from input-output tables. The advantage of using plant-level time-varying measures of the intensity of service usage is that these enable us to better identify the heavy users of services within manufacturing and to account for the substantial increase in the usage of services by manufacturing plants in Chile over the sample period.

By considering the potential role of knowledge spillovers from service providers to manufacturing users, our study also relates to the literature on vertical spillovers from

[2] Markusen et al. (2005) also show important GDP gains from services liberalization based on general equilibrium simulations for a hypothetical country. In their model, the presence of foreign-owned service providers allows final goods producers to rely on more specialized expertise.

[3] This increase in the number of services increases the TFP of manufacturing firms through a Dixit-Stiglitz-Ethier framework (Dixit and Stiglitz, 1977; Ethier, 1982).

manufacturing FDI, which are shown to be more important than horizontal spillovers by Javorcik (2004), Kugler (2006), Blalock and Gertler (2008), and Marcin (2008). A rationale provided in this literature for vertical forward linkages is that foreign suppliers provide assistance and complementary services to local buyers.

The remainder of the chapter proceeds as follows. Section 2 describes recent trends in FDI in services in Chile. Section 3 discusses the expected effects of FDI in services and the available evidence. Section 4 describes the data. Section 5 describes our empirical specification. Section 6 discusses our main results and the robustness checks. Section 7 discusses extensions to our main results. Section 8 concludes.

2. Trends in FDI in Services in Chile

Over the last three decades, liberalization, privatization, and deregulation reforms in Chile opened its economy to trade and investment more than any other country in Latin America (Moreira and Blyde, 2006).[4] In the 1980s, most FDI inflows were related to Chile's comparative advantage in the extraction and processing of natural resources. However, during the 1990s, FDI inflows into service sectors take on a leading role.[5] Electricity and water, transport and telecommunications, and business services represent about 60% of net FDI inflows into Chile during the 1996-2001 period. Figure shows that these substantial FDI inflows resulted in a growing FDI stock in the main service sectors in Chile. Also, the ratio of FDI to output increased substantially in most Chilean service sectors over the 1990s, as shown in Figure.[6]

[4] FDI in Chile is governed by Decree Law 600 in place since 1974 which regulates conditions for market entry, capitalization, and foreign capital remittances (ECLAC, 2000). The decree law grants equal treatment to foreign and domestic investments in mining, manufacturing, and most service sectors, the exceptions being professional services such as engineering, or legal services (Moreira and Blyde, 2006).

[5] FDI inflows achieved a peak in 1999 in the electricity and water sector due to the purchase of Enersis and Endesa-Chile by the Spanish electricity firm Endesa-Spain (ECLAC, 1999).

[6] The computation of the variables shown in Figures 1 and 2 is described in Section 4 and in the Appendix.

The large FDI inflows in Chile during the 1990s reflect first and foremost the worldwide increase in FDI in services mainly motivated by the interest of multinationals (MNCs) in becoming global service providers by gaining access to domestic and regional markets, particularly in the developing world (UNCTAD, 2004). In sectors such as electricity, Chilean firms were privatized before 1990 and later acquired by foreign players. Global MNCs identified Chile's largely privately-owned firms as an attractive investment opportunity to consolidate their positions in Latin America (ECLAC, 2000).

3. The Effects of FDI in Services

FDI in services can provide various benefits to the host country: price changes, quality improvements, increased variety, and knowledge spillovers.[7] Next, we describe each benefit and the evidence of their presence in Chile or in developing countries more generally.

3.1 Effects on the Service Sector

First, FDI in services is likely to increase competition in local markets and result in price reductions. The reason is that incumbent firms - particularly in electricity and telecom sectors - no longer retain the rents they obtained from being previously monopoly providers. The available evidence confirms price decreases for Chile. In the telecom sector, Stehmann (1995) argues that FDI led to more competition, particularly in the long-distance market where MNCs entered early. In the electricity sector, Pollitt (2004) shows price declines during the 1990s. For a group of 80 countries including

[7] Note that FDI in services can also entail potential costs: (1) foreign ownership in inherently monopolistic sectors such as electricity or telecom may result in higher prices unless the regulatory system is very well defined and managed by the government, and (2) foreign ownership may crowd out domestic firms for example in the banking sector (UNCTAD, 2004).

Chile, Claessens et al. (2001) find that increased foreign equity shares in the banking sector led to stronger competition and reduced margins from 1988 to 1995.

Second, FDI in services may lead to service quality improvements. These may result from increased competition and the superior technological, organizational, and managerial know-how of foreign service providers.[8] The superiority of services MNCs is akin to that of manufacturing MNCs and is based on their ownership of intangible assets such as management or marketing techniques (Dunning 1993). In the electricity and telecom sectors, quality relates also to the reliability of service provision. FDI can provide the necessary finance for the major investments required for upgrading and expanding existing networks. UNCTAD (2004) provides evidence of a positive impact of FDI on the reliability of services in Latin America during the 1990s. World Bank (2004) shows improved service quality in the electricity sectors of Latin American countries as a result of privatization often to foreign MNCs and of deregulation.

Third, FDI in services may result in greater variety of services being provided, including new and technologically advanced services or services provided to new regions or new types of clients. Evidence of an increased number of innovative financial products available and of electronic banking techniques as a result of FDI in the banking sector is provided e.g., by Cardenas et al. (2003) for Mexico. ECLAC (2000) shows that FDI in the Chilean telecom sector led to the provision of a wider range of products and services in addition to an increase in the number of telephone lines.

Fourth, FDI in services may result in leaking of managerial, marketing, and organizational know-how and best practices (e.g., linked to the environment or to labor codes) from foreign to domestic providers. Miroudout (2006) documents these

[8] For a set of developing countries, Shelp et al. (1984) describe the process of technology transfer from MNCs parents to their affiliates in the insurance and engineering and consulting service sectors.

knowledge spillovers for the banking, telecom, and transport sectors across developing countries.

The four potential effects from FDI in services - price reductions, quality improvements, increased variety, and knowledge spillovers - are likely to stimulate productivity growth within the service sector, for both foreign and domestic providers. The fact that MNCs may have acquired the best performing services firms (some privatized since the late 1980s) instead of opening new subsidiaries could reduce the potential for positive effects of FDI on the performance of Chilean services firms. Nevertheless, the evidence suggests that those positive effects materialized for example in the Chilean electricity sector which exhibits significant improvements in labor productivity due to FDI during the 1992-2002 period (Pollitt, 2004).

3.2 Effects on the Manufacturing Sector

The crucial hypothesis that we test in this chapter is whether the aforementioned FDI-induced improvements in service sectors benefit the TFP growth of downstream manufacturing users. If present, these dynamic benefits could be classified as pecuniary (rent) spillovers which are a by-product of market transactions (Griliches, 1992). Manufacturing plants benefit from pecuniary spillovers if they use services and the increases in quality or variety as a result of FDI are not fully appropriated by service providers.[9] For service sectors which tend to be characterized by imperfect competition, providers may not appropriate the full surplus from better and more diversified services because of their inability to perfectly price discriminate. If FDI increases the degree of competition in service sectors, then competitive pressures may prevent service providers

[9] Moreover, increases in the quality or variety of services may not be incorporated in services price deflators.

from appropriating that surplus. In both cases, service providers charge a price that is lower than that corresponding to the quality of the services provided.

FDI in services can also benefit manufacturing plants through spillovers of 'soft technology' linked to managerial, organizational, or marketing know-how and technical skills. Learning by manufacturing plants could result from demonstration effects, personal contacts, manager or worker turnover.[10] Griliches (1992) distinguishes knowledge spillovers from pecuniary spillovers since in principle only the former allow manufacturing plants to use that knowledge to advance their own innovation capabilities. While this is a conceptually clear distinction, in practice pecuniary spillovers may become knowledge spillovers if downstream users of better services apply the embodied knowledge to improve their own TFP growth (Branstetter, 2001). First, for knowledge-intensive business services such as marketing, technical, and other consultancy services (e.g., information technology (IT) related), the actual service provided *is* a knowledge-intensive input upon which manufacturing plants may rely to improve their innovation capabilities and TFP growth (Kox and Rubalcaba, 2007).[11] The capability of routine problem-solving as part of everyday project work and the instructions and know-how for installing and using new equipment and systems exemplify knowledge flows between a business services provider and its manufacturing client (Den Hertog, 2002). Second, the usage of newer services (e.g., internet banking) may embody technological knowledge which allows manufacturing plants to improve their production and operations (e.g., by increasing the efficacy of their IT investments). Third, the aforementioned increased reliability of service provision resulting from FDI

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[10] See Malerba (1992) on interactions with suppliers as a spur for incremental technical change by plants.

[11] The providers of knowledge-intensive business services can act as facilitators of innovation for manufacturing plants by sharing with them experience and ideas on best practice solutions for technological and business problems based on their observation of localized tacit knowledge across their clients (Muller and Zenker, 2001).

may allow manufacturing plants to optimize their machinery usage (e.g., production processes are less disrupted due to electricity outages) and provide incentives for plants to use technologically more advanced production processes which depend on telecom or internet/data connection. These possibilities capture multiple dimensions of technological change thus motivating a positive effect of FDI in services on plant TFP growth and also epitomize the overlap between pecuniary and knowledge spillovers which will characterize our main results.

4. Manufacturing Plant-Level Data

The main dataset used in our analysis is the Encuesta Nacional Industrial Annual (ENIA), which is the annual manufacturing survey of Chilean plants with more than 10 employees. The dataset is an unbalanced panel capturing plant entry and exit covering the 1992-2004 period and including an average of 4913 plants per year classified into 4-digit ISIC revision 2 industries.[12] The Appendix provides details on how the final sample of 57025 observations is obtained. The ENIA survey collects plant-level information on sales, employment, raw materials, investments (buildings, machinery and equipment, transportation, and land) which are used to construct output and inputs for the production function discussed in Section 5. All nominal variables are expressed in real terms using appropriate deflators and capital is constructed applying the perpetual inventory method formula, as described in the Appendix.

A particularly interesting feature of the ENIA survey is that it collects information on plant-level expenditures on a variety of services: advertising, banking commissions and interest payments, communications, insurance, legal, technical, and accounting

[12] The ENIA dataset has been widely used in research e.g., by Pavcnik (2002), Alvarez and Lopez (2005), and Bergoeing and Repetto (2006). While the dataset provides information by plant according to Pavcnik (2002) more than 90% percent of Chilean firms during the 1979-1986 period were single-plant firms. Thus plant data corresponds to a large extent to firm data.

services, licenses and foreign technical assistance, rental payments, transport, other services, electricity, and water. This information allows us to include a bundle of services (excluding electricity) appropriately deflated as inputs in the production function discussed in Section 5. For electricity, the quantity consumed is the input included. This information also enables us to construct plant-specific time-varying weights representing the intensity of service usage, as detailed in Section 5.2.

5. Empirical Specification

5.1 Basic Framework

In this section we present the reduced form framework used to estimate the impact of FDI in services on the TFP growth of Chilean manufacturing plants. We consider a Cobb-Douglas production function in logarithms for plant *i* in industry *j* at time *t* as in:

$$\ln Y_{it}^{j} = \ln A_{it}^{j} + \eta_{SL}^{j} \ln SL_{it}^{j} + \eta_{UL}^{j} \ln UL_{it}^{j} + \eta_{M}^{j} \ln M_{it}^{j} + \eta_{E}^{j} \ln E_{it}^{j} + \eta_{s}^{j} \ln S_{it}^{j} + \eta_{K}^{j} \ln K_{it}^{j}, \quad (1)$$

where Y_{it}^{j} is output, SL_{it}^{j} is skilled labor, UL_{it}^{j} is unskilled labor, M_{it}^{j} is materials, E_{it}^{j} is electricity, S_{it}^{j} is services, K_{it}^{j} is capital, and A_{it}^{j} is a plant-specific index of Hicks-neutral TFP measuring the plant's efficiency in transforming inputs into output.

The crucial hypothesis tested in this chapter is whether FDI in services affects plant TFP growth. This effect could result from pecuniary spillovers showing up in measured TFP growth through unaccounted for increases in services quality and variety. Equally important is the possibility that FDI in services generates knowledge spillovers for manufacturing users, and pecuniary spillovers can result in knowledge spillovers. Thus, we allow plant TFP growth $d \ln A_{it}$ (ignoring the industry subscript *j*) to depend on a service FDI linkage measure $FDIsl_{it-1}^{j}$ as:

$$d \ln A_{it} = \beta_{fdi\_s} FDIsl_{it-1} + \gamma_Z Z_{it-1} + \varepsilon_{it}, \qquad (2)$$

where Z_{it-1} is a vector of control variables discussed in Section 5.3, and ε_{it} is a stochastic residual. A positive β_{fdi_s} indicates a beneficial impact of FDI in services on plant TFP growth. Before discussing the econometric issues associated with the estimation of Equation (2), we present our service FDI linkage measure.

5.2 Service FDI Linkage Measure

To estimate the effects of FDI in services on manufacturing TFP growth, we make the working hypothesis that Chilean plants that are relatively heavy users of services should (ceteris paribus) benefit disproportionately more from increases in FDI in services than plants that are less heavy users of services.[13] To capture the intensity of service usage by plants, we compute the ratio of plant expenditures on four categories of services (henceforth designated as four service sectors) - (1) electricity and water, (2) transport and communications, (3) financial, insurance, and business services, and (4) real estate - to plant sales.[14] Information on a plant's usage of foreign-provided services as separate from domestic-provided services would be the ideal measure to use. However, to the extent that domestic service providers increase their quality and variety and lower their prices due to the presence of FDI in their sector - through increased competition or knowledge spillovers - total service usage adequately captures the benefits which a Chilean manufacturing plant may derive from service usage for its TFP

[13] This assumption is inspired by that made by Rajan and Zingales (1998) in the estimation of the benefits of access to finance for industry growth. Our assumption implies that cost is the only limitation to purchase services and that there are no other restrictions preventing the access to certain services by certain users.
[14] Business services encompass advertising, legal, technical, and accounting services, licenses and foreign technical assistance, and other services. These four groups of services are dictated by the availability of sectoral GDP from the Chilean Central Bank used below.

growth beyond the contribution that the services input per se generates for the plant's output.

To capture the presence of FDI, we compute for each service sector net FDI inflows based on data from the Chilean Foreign Investment Committee by subtracting from annual FDI inflows the corresponding annual FDI outflows (i.e., foreign investors' repatriation of capital, profits, and dividends). Net FDI inflows however do not adequately capture the importance of FDI in a service sector and year because they neither account for past investments nor for the sector's size. Thus, we cumulate net FDI inflows using the perpetual inventory method formula to construct an FDI stock for each sector, as described in the Appendix.[15] Our measure of FDI penetration in a service sector is given by the ratio of the sector's FDI stock to the sector's output (GDP) obtained from the Chilean Central Bank.

Our final plant-level time-varying service FDI linkage measure that captures both the presence of FDI in services and plant usage of those services is computed as: $FDIsl_{it} = \sum_{k=1}^{K} \alpha_{it}^{k} * FDI_{kt}$, where FDI_{kt} is the FDI penetration ratio in service sector k in year t which is weighted by α_{it}^{k} the intensity of usage of services from sector k by plant i in year t. The sum is computed over the four aforementioned service sectors. More details on the construction of the service FDI linkage measure are provided in the Appendix.

Our service FDI linkage measure is inspired by the measures used by Javorcik (2004), Blalock and Gertler (2008), and Arnold et al. (2007a), but differs from those by relying on a plant-level time-varying intensity of service usage instead of service usage

[15] Our approach is similar to that followed to construct R&D stocks (Coe and Helpman, 1995).

measures based on input-output coefficients. A first shortcoming of measures based on input-output tables is that they provide information on average industry usage which does not identify the heavy users of services within the industry. Panel A of Figure shows a large degree of heterogeneity in the average intensity of service usage across 2-digit industries in Chile. Unreported variance decomposition results suggest, however, that almost all of the variation in the average intensity of service usage is due to variation across plants within industries rather than across industries. A second shortcoming of measures based on input-output tables is that they provide information for a single year which is particularly restrictive for service usage during our sample period when the linkages between services and manufacturing resulting from processes of outsourcing or splintering increased dramatically (Francois and Woerz, 2007). Panel B of Figure confirms this trend for Chile by showing that the average intensity of service usage - especially business services - increased substantially over the sample period.

5.3 Econometric Issues and Final Specification

First, to address the potential endogeneity between input choices - particularly the choice of service inputs - and plant unobserved productivity, we estimate our production function (Equation (1)) following the Levinsohn and Petrin (2003) methodology (henceforth LP). The estimation is performed separately for each 2-digit industry to allow for differences in production technology across industries. Based on the consistent LP estimates, we obtain plant-level time-varying logarithmic TFP measures as residuals from Equation (1) and the corresponding first differences are our dependent variable in Equation (2).[16]

Second, it is possible that plant unobservables such as managerial ability may affect both plant TFP growth and the service FDI linkage measure through an impact on the intensity of service usage component of that measure. To address this possibility, we allow the residual ε_{it} in Equation (2) to include a plant-specific component f_i such that $\varepsilon_{it} = f_i + u_{it}$, where u_{it} is an independent and identically distributed (i.i.d.) disturbance. Hence, our final specification is estimated by plant fixed effects.

Third, two issues could raise the possibility of endogeneity of the FDI penetration component of the service FDI linkage measure with respect to TFP growth. One issue is that manufacturing industries experiencing fast TFP growth may lobby the government for services liberalization. However, since Chile's FDI regime was liberal since the 1980s, lobbying by manufacturing industries for services liberalization would have occurred well before our sample period and is thus unlikely to be a source of bias for our coefficient of interest.[17] Another issue is that the TFP growth of manufacturing plants in Chile in the 1990s may have been a driving force for service MNCs to invest in Chile in expectation of strong demand for services. While ECLAC (2004) argues that foreign investors were attracted by the sound performance of recently privatized services firms in Chile, there is no clear evidence that the performance of the manufacturing users of those services was a driving force for FDI. Nevertheless, strong TFP growth in some manufacturing industries in Chile may have provided an additional incentive for MNCs to invest in the country's service sectors. Our final empirical specification includes the

[16] For brevity we do not report the LP estimates but they are available in Fernandes and Paunov (2008). They are generally significant and have magnitudes in line with those in previous studies.
[17] In fact, one may even question whether such lobbying played any role given that the privatization of service firms starting in the late 1980s was partly motivated by the need to solve a public deficit problem (Bitran and Saez, 1994).

service FDI linkage lagged two periods, instead of being lagged one period as in Equation (2). The question that arises is whether the two-period lagged service FDI linkage is exogenous to current plant TFP growth. This would not be the case if plant TFP growth was serially correlated over time. While plant productivity *levels* tend to exhibit strong serial correlation in micro datasets, this is not expected for plant productivity *growth*. Indeed, our tests for first-order autocorrelation in plant TFP growth based on the Baltagi-Wu locally best invariant (LBI) test show no evidence of serial correlation. We therefore argue that the use of a service FDI linkage measure based on FDI stocks and lagged two periods is a reasonable way to mitigate potential reverse causality problems.

Fourth, time-varying plant- or industry-level observable factors could be correlated with the service FDI linkage and with plant TFP growth and their omission could bias our coefficient of interest. The service FDI linkage in Equation (2) could be proxying for the effects of FDI in manufacturing or mining. To address this possibility, we include in our final specification FDI linkage measures for manufacturing and mining whose construction is described in the Appendix. The coefficient on the service FDI linkage could also pick up differences in service usage by foreign-owned, exporting, or larger plants, which in turn may exhibit different TFP growth than other manufacturing plants. Hence, we include in the vector Z_{it-1} dummies to control for foreign ownership, exporter status, and plant size.[18]

Finally, certain manufacturing industries may experience faster technological progress or changes in their market structure relative to other industries, with potential

[18] Three size categories are considered: small plants (1-50 employees), medium plants (50-200 employees), and large plants (200 or more employees). But the results are robust to the use of alternative size categories.

consequences for plant TFP growth. Chilean regions may also exhibit differential growth rates over time due to the evolving nature and importance of agglomeration economies. To account for these possibilities, we add 2-digit industry-year interaction effects and region-year interaction effects to Equation (2).

The considerations above lead to our final empirical specification:

$$d\ln A_{it} = \beta_{fdi\_s} FDIsl_{it-2} + \gamma_{fdi\_i} FDIndl_{jt-2} + \gamma_{fdi\_r} FDIres_{jt-2} + \gamma_z Z_{it-1} + \gamma_{ind} ind*year + \gamma_{reg} reg*year + f_i + u_{it}, \quad (3)$$

where $FDIsl_{it-2}$ is the two-period lag of the service FDI linkage, $FDIl_{jt-2}$ and $FDIres_{jt-2}$ are the two-period lag of the manufacturing and the mining FDI linkages, *ind*year* and *reg* year* are 2-digit industry-year and region-year interaction fixed effects, respectively, and u_{it} is an i.i.d. residual.[19] The vector Z_{it-1} includes dummies for foreign ownership, export status, and size.

6. Results

6.1 Main Results

Our main results are shown in Table 1. Column 1 presents the results from a plant fixed-effects specification that follows previous studies in weighing service FDI penetration by 4-digit industry-level service usage measures which are based on industry-level expenditures in services relative to sales, as detailed in the Appendix. We find positive but insignificant effects of that measure of weighted service FDI penetration on plant TFP growth. In Column 2, we estimate a variant of Equation (3) including only the one-period lag of the service FDI linkage measure. We find a strong

[19] The mining and manufacturing linkage measures are indexed by the industry subscript *j* instead of *i* since they are constructed based on coefficients from the 1996 Chilean input-output table, as described in the Appendix.

positive effect of FDI in services on plant TFP growth. Since the specification in Column 2 does not take into account potential endogeneity, the effect of FDI in services on TFP growth is likely to be over-estimated. Indeed, the use of the two-period lag of the service FDI linkage measure in Column 3 reduces substantially the magnitude of the effect. However, the estimated coefficient on the service FDI linkage is still positive and significant at the 1% confidence level. In Column 4 we add the manufacturing and mining FDI linkage measures and find the coefficient on the service FDI linkage to be unaffected. Finally, Column 5 estimates the complete empirical specification in Equation (3) which controls for plant-level observables, industry-year and region-year interaction effects and is our preferred specification. The standard errors in Table 1 and all subsequent tables are robust and clustered at the plant-level to allow for possible correlation across observations belonging to the same plant.[20] The plant fixed effects are found to be jointly significant in all our specifications. Our choice of plant fixed effects estimation is driven by the results from Hausman tests which reject random effects in favor of fixed effects for our specifications.

Our findings indicate that increased FDI in services in Chile during the 1992-2004 period led to a significant increase in TFP growth for the plants that use services more intensively. Our preferred coefficient in Column 5 (0.149) implies that the average increase in the service FDI linkage over the sample period (0.073) added 1.1 percentage points to annual plant TFP growth in Chile, all else constant. To quantify further the economic impact of FDI in services, note that, based on our estimates, TFP growth

[20] The use of non-clustered robust standard errors or other levels of clustering - at the year level, at the 3-digit industry level and at the 3-digit industry-year level - does not affect the significance of our results.

increased by about 29% between 1992 and 2004 in the Chilean manufacturing sector.[21] Thus, our preferred coefficient implies that the forward linkages from FDI in services explain almost 4% of the observed increase in Chile's manufacturing users' TFP growth. This economic impact is quite meaningful in light of the finding by Haskel et al. (2007) that spillovers from manufacturing FDI explain 5% of manufacturing TFP growth in the U.K. between 1973 and 1992. Moreover, in Chile, a large fraction of inflows of FDI into service sectors consisted in the acquisition of incumbent service providers, some of which were privately-owned since the late 1980s, thus our impact is likely to underestimate the potential impacts in countries where FDI inflows are directed at the privatization of service providers or at the creation of new service providers.

One may argue that the estimated effect of the service FDI linkage measure on Chilean manufacturing plants' TFP growth captures not only the benefits from the openness of service markets to FDI but also those from contemporaneous regulatory reforms affecting those sectors. To address this concern we exploit regional differences in FDI. Specifically, we construct a regional service FDI linkage measure following the same approach as in Section 5.2 based on regional FDI inflows data and output data and making use of each plant's location, as described in the Appendix. Column 6 of Table 1 shows the results from including this regional service FDI linkage measure in Equation (3). Since regulatory reforms are applied uniformly across Chile while FDI in services is unevenly distributed across regions, the positive and significant coefficient on the regional service FDI linkage measure in Column 6 demonstrates that our main effects capture to a large extent the impact of FDI.

[21] To obtain TFP growth for the manufacturing sector over the sample period we proceed in two steps. First we compute for each year a weighted average TFP growth which weighs each plant's TFP growth by the plant's share in total sales of the manufacturing sector in that year. Second, we sum this weighted average TFP growth from 1994 to 2004 to obtain a measure of manufacturing sector TFP growth over the estimating sample period.

6.2 Robustness Checks

While we believe that our service FDI linkage measure captures the importance of FDI in services in Chile, we verify whether our results are robust to modifications in that measure's definition. We modify the two components of our linkage measure: the service FDI penetration (either the numerator or the denominator) and the plant-level weights. Columns 1 and 2 of Table 2 report the results from computing the numerator of the service FDI penetration - FDI stocks - using depreciation rates of 0% and 10%, respectively, which differ from the rate used in our main measure. Columns 3 and 4 of Table 2 report the results from modifying the denominator of the service FDI penetration - time-varying sectoral GDP - to be either replaced by the time-varying economy-wide GDP (column 3) or dropped (column 4).[22] Each of these alternative service FDI penetration measures is interacted with the same plant-level weights as in our main measure. Across all specifications, we find the coefficient on the service FDI linkage to be positive and significant. The last two columns of Table 2 report the results from using service FDI linkage measures based on alternative measures of the intensity of service usage by plants. In Column 5 we subtract from the plant-level weights the time-varying median service usage in the plant's 3-digit industry. In Column 6, we define plant-level service usage relative to total revenues instead of total sales. The coefficient on the service FDI linkage remains in both cases positive and significant.

As an additional check on the validity of our working hypothesis - that relatively heavy users of services should benefit disproportionately more from service FDI increases - we generate 1000 groups of random plant-level time-varying services intensity weights, recompute our service FDI linkage measure using those random

[22] In column 4 the service FDI penetration measure is therefore simply the log of the service FDI stock.

weights, and estimate Equation (3) 1000 times, following the simulation exercise in Keller (1998).[23] The average coefficient on the recomputed service FDI linkage is negative and insignificant suggesting that that the intensity of service usage by plants does matter for the estimated impact of the service FDI linkage measure on the TFP growth of Chilean plants.

Table 3 shows the results from additional robustness tests. First, given the inherent difficulty and controversy associated with the estimation of production functions (Bond and Söderbom, 2005) and to ensure that our strong positive effects of FDI in services are not due to the use of a particular TFP growth measure, we consider four alternative measures. In Column 1, we estimate a specification which differs from Equation (3) in that plant output growth is the dependent variable and growth in each of the six inputs (shown in Equation (1)) are additional independent variables. We allow the coefficients on growth in each of the six inputs to differ across 2-digit industries. The estimated effect of the service FDI linkage on plant productivity growth (i.e., output growth controlling for input growth) is still positive and significant and close in magnitude to that in column 5 of Table 1. In Column 2, we estimate a production function separately for each 2-digit industry following the Olley and Pakes (1996) methodology and use the first difference in the corresponding residual plant TFP as dependent variable in Equation (3). The results show a positive and significant effect of the service FDI linkage on plant TFP growth which is smaller than that estimated in Column 5 of Table 1.

It is important to discuss that recently important shortcomings in the methodologies of the popular semi-parametric production function estimation techniques

[23] We follow Keller (1998) in drawing the random plant-level time-varying services intensity weights from a uniform distribution with support [0,1] using the pseudo random number generator of the GAUSS software.

proposed by Olley and Pakes (1996) and specifically the one proposed by Levinsohn and Petrin (2003) have been unveiled that seriously put their use in question. Ackerberg et al. (2006) propose on the grounds of those shortcomings an alternative estimation method we will use here to see whether our results may have been driven by the estimation problems of the Levinsohn and Petrin (2003) and Olley and Pakes (1996). Before outlining results we will explain the main principles of each and the methodological problems and solution proposed by Ackerberg et al. (2006) to obtain valid production function estimates:[24] The major concern the semi-parametric estimation techniques proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) address is potential endogeneity. To explain their proposed solution, let us specify the following Cobb-Douglas production function:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it} \qquad (4)$$

where *y* is log of output, *k* is log of capital input and *l* is log of labor input of firm *i* at time *t*. The problematic element of this equation is ω as it represents shocks that are observable to the firm but unobservable to the econometrician and will, if they impact firm input decisions, lead to biased estimates of β_k and β_l if estimated using OLS.

Olley and Pakes (2003) specify a model of firms that maximize the present discounted value of profits. Shocks ω_{it} are assumed to evolve exogenously following a first-order markov process, i.e. $p(\omega_{it+1} \mid I_{it}) = p(\omega_{it+1} \mid \omega_{it})$ where I_{it} is firm *i*'s informations et at *t*. They further assume that labor decisions taken at *t* do not impact future profits of the firm while the capital stock, determined by past investment decisions (i.e. $k_{it} = \kappa(k_{it-1}, i_{it-1})$), is a dynamic input. According to this formulation the

[24] The description of major methodological problems follows the excellent explanation provided by Ackerberg et al. (2006). More detail is provided in their paper.

capital stock at t is, therefore, an outcome of decisions taken at t-1. The allows addressing the endogeneity problem with respect to capital using the fact that k_{it} is uncorrelated with ω_{it} between t-1 and t.

The same logic cannot be applied to identify β_l as the decision on labour inputs is taken at t and thus potentially correlated with ω_{it}. If firm's optimal investment level is a strictly increasing function of current shock ω_{it}, i.e. $i_{it} = f_t(\omega_{it}, k_{it})$, then given strict monotonicity of the investment function in ω_{it} we can obtain the following:

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}) \tag{5}$$

The idea is to use this function to control for unobserved ω_{it} to obtain unbiased estimates of β_l. The production function obtain by substituting ω_{it} then becomes:

$$\begin{aligned} y_{it} &= \beta_k k_{it} + \beta_l l_{it} + f_t^{-1}(i_{it}, k_{it}) + \varepsilon_{it} \\ &= \beta_l l_{it} + \Phi_t(i_{it}, k_{it}) + \varepsilon_{it} \end{aligned} \tag{6}$$

This is the first estimation stage for Olley and Pakes (1996) that obtains an estimate of coefficient β_l. and an estimate of $\Phi_t(i_{it}, k_{it})$. The inverted function f_t^{-1} is treated non-parametrically to avoid complicated dynamic programming problems. This, however, has the downside that β_k cannot be obtained as k_{it} is collinear with the non-parametric function. The estimate of coefficient β_k is obtained in the second stage using the exogtenous variation of k_{it} conditional on w_{it-1} as mentioned above. More detail is provided in Caves and Olley and Pakes (1996).

The method proposed by Levinsohn and Petrin (2003) is very similar with the main difference that they use an intermediate input demand function to "invert" out ω_{it}. The main motivation is that investment is in practice very lumpy and many firms will have zero investment in several time periods. Olley and Pakes (1996) could then only be applied if zero investment cases are discarded which could lead to sample biases in production function estimates. Their baseline production function is specified as:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \varepsilon_{it} \tag{7}$$

where m_{it} is an intermediate input. The intermediate demand function takes on the same role investment holds (based on the same assumptions as) in Olley and Pakes obtaining $\omega_{it} = f_t^{-1}(m_{it}, k_{it})$. The term will then included in the first stage obtain estimates of β_l. The second stage is roughly similar to Olley and Pakes (1996) with the additional complication that an additional coefficient has to be estimated. More detail on the method is provided in Levinsohn and Petrin (2003).

The crucial problem Ackerberg et al. (2006) identify for both methodologies as originally specified is the first stage estimate of coefficient β_l. A consistent estimate of β_l would require the labour input decision to vary independently of $f_t^{-1}(m_{it}, k_{it})$ or $f_t^{-1}(i_{it}, k_{it})$ depending on which of the two methods is used. Focusing for the purposes of exposition on the former case, since both input and labour decisions are taken simultaneously and similarly do not affect future profits directly they are likely determined in very similar ways, i.e. as $m_{it} = f_t(\omega_{it}, k_{it})$ we likely have $l_{it} = g_t(\omega_{it}, k_{it})$. It follows that $l_{it} = g_t(f_t^{-1}(m_{it}, k_{it}), k_{it}) = h_t(m_{it}, k_{it})$. This means that there is a serious collinearity problem in the first stage making it impossible to obtain an estimate of both β_l and of a non-parametric function as both are function of the same variables (ω_{it}, k_{it}). This casts serious doubt on both methods at least the way they were originally proposed.[25] The approach by Ackerberg et al. (2006) proposes is similar to the methods proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) in that it uses

[25] Ackerberg et al. (2006) discuss alternative specifications for both Olley and Pakes (1996) and Levinsohn and Petrin (2003) methods that would solve the collinearity problems of the original specifications.

investment/intermediate inputs as "proxies" for investment shocks. The main difference is that the first stage is not used to obtain estimates of the labour coefficient. Further detail on how the second stage is used to obtain those coefficients can be found in Ackerberg et al. (2006).

In Column 3, we estimate a production function separately for each 2-digit industry following Ackerberg et al. (2006) methodology which addresses potential collinearity problems from which the LP methodology may suffer.[26] Using as dependent variable in Equation (3) plant TFP growth based on the corresponding residual TFP levels we find again a positive and significant effect of the service FDI linkage. Column 4 shows the results from using as dependent variable in Equation (3) a growth accounting index measure of plant TFP growth as advocated by Van Biesebroeck (2007) where the contribution of growth in each input to output growth is given by a two-period moving average of plant-level shares of each input in total sales, as described in the Appendix. This approach has the advantage of allowing the technology to change over time and within industries. The coefficient in Column 4 shows a positive and significant effect of the service FDI linkage of a larger magnitude than those in other columns and tables. Note that when we consider a translog functional form for our production function, the results show a positive and significant coefficient on the service FDI linkage of a similar magnitude as those discussed above.[27]

Second, to address further the potential reverse causality between service FDI linkage and TFP growth estimate Equation (3) including the three-period lag of the service FDI linkage and show in Column 5 that it has a positive and significant effect on TFP growth. Third, despite being confident in the appropriateness of the data cleaning

[26] The Olley and Pakes (1996) and Ackerberg et al. (2007) production function coefficients are available upon request.
[27] These results are available from the authors upon request.

procedures applied to the Chilean data described in the Appendix, we impose a much more stringent criterion to guarantee that our results are not being driven by remaining potential outlier observations.[28] In Column 6 we drop from the sample plants whose TFP growth is in the top or bottom percentile of the distribution and find that the estimated effects of the service FDI linkage are still positive and significant.

Fifth, while the industry-year interaction effects included in our preferred specification account in a general way for industry-specific technological progress and competition, we replace those by an observable measure of the degree of competition, the normalized Herfindahl index of plant market shares at the 3-digit industry level in Column 7. The estimates show a positive and significant effect of the service FDI linkage on plant TFP growth. The effect of competition on TFP growth is found to be positive but insignificant.[29]

Finally, one concern for the interpretation of our main results relates to the composition of the service FDI linkage measure. One could argue that the stronger usage of services by some plants is what is driving up their TFP growth (and thus producing our estimated positive effects in Tables 1 to 3), rather than the presence of FDI in those service sectors. We should recall that our plant TFP growth measures are obtained correcting for the simultaneity bias between service input choices and TFP, and our specifications are estimated by plant fixed effects to control for further problems of endogeneity between plant service usage and plant TFP growth. Anyway, to address this issue further we estimate a variant of Equation (3) and perform a simulation exercise. The variant separates the service FDI linkage into its four components listed in Section

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[28] Note that we obtained qualitatively similar results to those in Table 1 when estimating Equation (3) using plant fixed effects or robust regression for a sample where outliers (as described in the Appendix) were not excluded.

[29] The results are also robust to the use of the market share of the top 4 plants in each 3-digit industry as the measure of the degree of competition.

5.2. The unreported results show positive effects of FDI in transport and communications, in financial, insurance, and business services, and in electricity and water with the strongest effect being that of financial, insurance, and business services. This finding on the importance of FDI in knowledge-intensive business services suggests that knowledge spillovers may be the major channel through which FDI in services is leading to TFP growth increases in Chilean manufacturing plants. Our simulation exercise follows Keller (1998) and consists of generating 1000 random time-varying FDI penetration ratios for the four services, recomputing our service FDI linkage measure using those random ratios, and estimating Equation (3) 1000 times.[30] The average coefficient on the recomputed service FDI linkage measure is positive though smaller than our estimate in Table 1 and it is insignificant suggesting that our estimated effect of FDI in services on the TFP growth of Chilean plants is not driven only by the stronger usage of services by some plants.

7. Heterogeneity in the Effect of FDI in Services

Our main findings concern the average impact of FDI in services on plant TFP growth across the Chilean manufacturing sector. However, the strength of that impact may differ across industries. First, we examine whether our results are driven by any particular industry. Table 4 shows the results from estimating Equation (3) excluding one 2-digit industry at a time. The estimates show that the positive effects of FDI in services on plant TFP growth are not driven by any industry, not even by food, the largest industry in Chile. However, they also show that the strength of the effects varies across industries.

[30] We draw random time-varying FDI penetration ratios for each of the four service sectors from a uniform distribution whose support ranges from 0 to the maximum FDI penetration ratio observed in our sample using the pseudo random number generator of the GAUSS software.

Second, we focus on one particular dimension of heterogeneity across industries: the degree of product differentiation in the industry. One can argue that differentiated product industries are characterized by stronger product complexity (Berkowitz et al., 2006).[31] As such, it is likely that service needs are greater for differentiated product industries. Thus, the TFP growth of plants in industries producing differentiated products may benefit more from FDI in services. To test this hypothesis, we use the differentiated product definition proposed by Rauch (1999).[32] We estimate our main specification allowing the effect of the service FDI linkage to vary across differentiated and non-differentiated product industries. The results in Column 1 of Table 5 suggest a stronger effect of FDI in services on the TFP growth of plants in differentiated product industries. However, the F-test shows that the difference in the effect of FDI in services across the two types of industries is not statistically significant.

Next, we allow for plant heterogeneity in the impact of FDI in services on TFP growth. First, we examine whether domestic plants benefit more from FDI in services than foreign-owned plants which may rely on the parent MNC for some services and thus have less to gain from FDI-related improvements in the domestic service sector. Column 2 shows the results from estimating Equation (3) for a sub-sample that includes only domestic plants. The magnitude of the service FDI linkage coefficient is unchanged relative to Column 5 of Table 1, suggesting that domestic and foreign plants benefit equally from FDI in services.

[31] The authors argue that differentiated products have many characteristics that are difficult to stipulate in a contract, thus trade in such products benefits more from good dispute resolution and enforcement institutions.

[32] Differentiated products are defined to be those that are neither (i) homogenous products traded in organized exchanges (e.g., steel) nor (ii) reference-priced products which have listed prices in trade publications (e.g., some chemical products) and require a more important degree of buyer-seller interaction. To apply Rauch's definition, we establish a correspondence between his classification of products based on 4-digit SITC rev. 2 codes and our 4-digit ISIC rev. 2 codes. For the printing industry (ISIC 342), we are unable to establish an unambiguous correspondence and thus drop the corresponding plants from the regression in Column 1 of Table 5.

Second, we ask whether the impact of FDI in services on TFP growth differs by plant size. On the one hand, larger plants may be able to internalize some services and have less to gain from FDI-related services improvements, relative to smaller plants which outsource most services due to scale indivisibilities. On the other hand, larger plants may be technologically more advanced and thus require stronger usage of highly specific and complex services. It is an empirical question whether smaller or larger plants benefit more from FDI in services. We estimate a variant of Equation (3) that allows the effect of the service FDI linkage measure to differ across small and large plants and show the results in Columns 3 and 4 of Table 5. In Column 3 we consider the plants with less than 25 employees as a median across their sample years to be small. In Column 4 we split the sample between plants with less than and more than 25 employees in their first sample year. The evidence is mixed depending on which criterion is used. Moreover, the corresponding F-tests show that the difference in the effects of FDI in services across smaller and larger plants is not statistically significant. Therefore, our findings in Tables 4 and 5 highlight the interesting fact that the positive effects of FDI in services in Chile are universal within the manufacturing sector across industries and types of plants.

8. Conclusion

This chapter examines the effects of FDI in services on the TFP growth of manufacturing plants in Chile between 1992 and 2004 by estimating a specification where plant TFP growth depends on a weighted service FDI penetration measure. The novelty of our approach is the reliance on measures of plant-level time-varying intensity of service usage as weights for service FDI penetration. Our results provide evidence of a positive and significant effect of FDI in services on the TFP growth of manufacturing plants that use services more intensively. Our findings are robust to alternative measures of TFP growth and to a variety of tests and are neither driven by any specific industry nor restricted to certain types of plants only.

Notwithstanding, it is important to highlight several caveats to our findings the reader should be aware of. Importantly, while introducing a two-period lag to our variable of interest helps address some endogeneity concerns – specifically the concern that foreign investment will be the more intensive as firms have stronger productivity growth (as it is hard for foreign firms to know growth two years ahead) - there is still a remaining endogeneity problem due specifically to the fact that we employ information on firms' use of services. If it is the case that firms with higher productivity growth tend to purchase more services, then it might be the case that our coefficient captures this reverse relationship rather than positive impacts of services. Moreover, a measure that arguably tells us more about the impact of foreign firms within a given industry is based on employment numbers in foreign companies to total employment rather than the stock of FDI to sectoral GDP ratio we use in this chapter. This type of information is, however, not available in the Chilean case. Finally, we do not have information on whether firms purchase services from foreign or local service providers. To the extent that we are interested in the overall impacts from foreign competition it is equally interesting to include local services uses. This is because one would not only expect foreign providers to contribute improved better quality products but also to lead to better services provisions by local firms. While we report evidence that such improvements took place, more quantitative information on the services sector would be helpful

While governments spend large sums to attract FDI inflows in expectation of spillovers, the literature focusing the manufacturing sector has provided mixed evidence:

relatively weak for horizontal spillovers and strong for vertical spillovers. Our study suggests that researchers may need to focus on the service sector to find strong positive spillover effects from FDI. Our findings also suggest that reducing the barriers that still protect FDI in services in many emerging and developing economies may help accelerate TFP growth in their manufacturing sectors.

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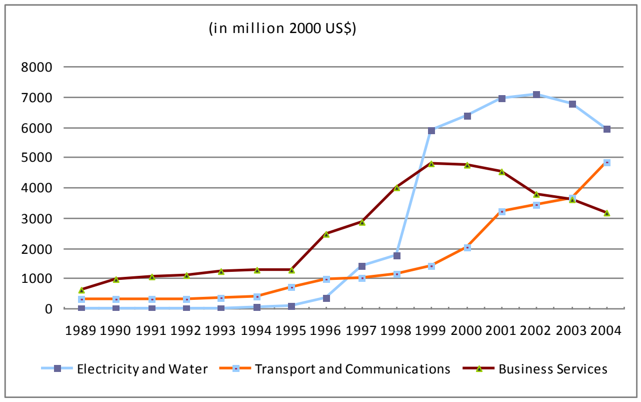
Chapter 2: Figures and Tables

Figure 1: Stocks of FDI in Chilean Service Sectors

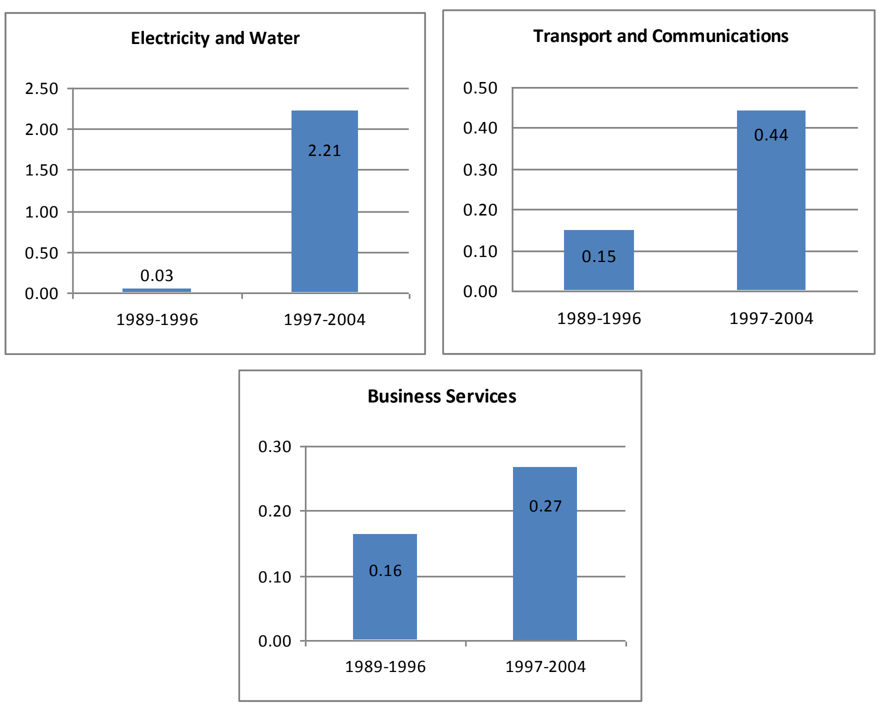


Source: Author's calculations based on data from the Chile Foreign Investment Committee.

Note: FDI stocks S^{FDI} for each service sector *k* in year *t* are computed using the perpetual inventory method

formula as $S_{kt}^{FDI} = NI_{kt}^{FDI} + (1-\delta)S_{kt}^{FDI}$, where *NI* denotes net FDI inflows and δ is the depreciation rate.

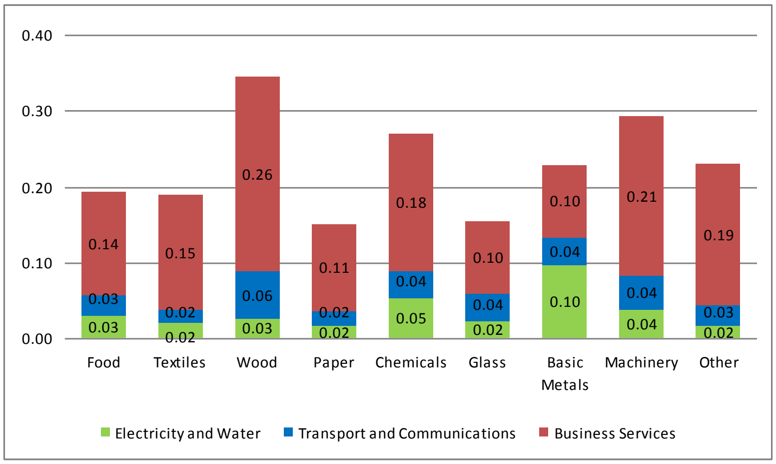
Figure 2: Average Ratio of Sectoral FDI Stocks to Sectoral GDP



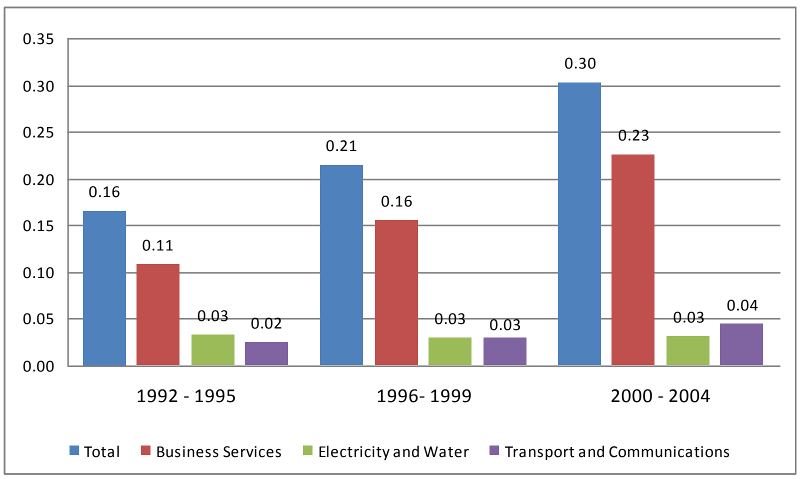
Source: Author's calculations based on data from the Chile's Foreign Investment Committee and the Central Bank.
Note: The figures show the average ratio of sectoral FDI stocks to sectoral GDP in each of the two time periods.

Figure 3: Intensity of Plant-Level Service Usage

Panel A. Averages across Industries



Panel B. Averages across Years



Source: Author's calculations based on ENIA survey data.
Note: In Panel A, the figure shows the average ratio of service usage to sales computed across plants over the sample period in each of the 2-digit industries. In Panel B, the figure shows the average ratio of service usage to sales computed across plants in all industries in each of the three time periods.

Table 1: Effect of FDI in Services on Plant TFP Growth

	Dependent Variable: Plant TFP Growth (Levinsohn and Petrin (2003))					
	(1)	(2)	(3)	(4)	(5)	(6)
Service FDI Linkage Industry	0.204					
	(0.280)					
Service FDI Linkage$_{t-1}$		0.567***				
		(0.078)				
Service FDI Linkage$_{t-2}$			0.142**	0.142**	0.149**	
			(0.060)	(0.060)	(0.060)	
Regional Service FDI Linkage$_{t-2}$						0.105**
						(0.042)
Plant Controls	Yes	No	No	No	Yes	Yes
Manufacturing and Mining FDI Linkages	Yes	No	No	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year Fixed Effects	Yes	No	No	No	Yes	Yes
2-Digit Industry*Year Fixed Effects	Yes	No	No	No	Yes	Yes
Number of Observations	38308	46439	38185	38185	38185	34803
R-Squared	0.03	0.02	0.01	0.01	0.03	0.03

Notes: Robust standard errors clustered at the plant level in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% confidence levels, respectively. Plant controls include exporter, FDI, and size dummies. The service FDI linkage measure in Column 1 is based on industry-level weights computed aggregating the plant-level data to the 4-digit industry level (as described in the Appendix) while that in Columns 2 to 5 is based on plant-level weights given by ratios of services expenditures to sales.

Table 2: Robustness to Changes in the Definition of Service FDI Linkage

	Dependent Variable: Plant TFP Growth (Levinsohn and Petrin (2003))					
	(1)	(2)	(3)	(4)	(5)	(6)
Service FDI Linkage - Deprec. Rate 0%$_{t-2}$	0.142***					
	(0.054)					
Service FDI Linkage - Deprec. Rate 10%$_{t-2}$		0.154**				
		(0.067)				
Service FDI Linkage - Den. GDP$_{t-2}$			1.792***			
			(0.660)			
Service FDI Linkage - No Den. Log$_{t-2}$				0.006***		
				(0.002)		
Service FDI Linkage - Wgt. Diff. to Ind. Median$_{t-2}$					0.150**	
					(0.060)	
Service FDI Linkage - Wgt. Revenues$_{t-2}$						0.151**
						(0.073)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes
Manufacturing and Mining FDI Linkages	Yes	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
2-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	38185	38185	38185	38185	38185	38185
R-Squared	0.03	0.03	0.03	0.03	0.03	0.03

Notes: Robust standard errors clustered at the plant level in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% confidence levels, respectively. The various service FDI linkage measures are described in the text. Plant controls include exporter, FDI, and size dummies.

Table 3: Additional Robustness Results

	Dependent Variable:						
	Plant Output Growth (Input Growth Controlled For)	*Plant TFP Growth (Olley and Pakes (1996))*	*Plant TFP Growth (Ackerberg et al. (2007))*	*Plant TFP Growth Index*	*Plant TFP Growth (Levinsohn and Petrin (2003))*	*Plant TFP Growth (Levinsohn and Petrin (2003))*	*Plant TFP Growth (Levinsohn and Petrin (2003))*
					3-Period Lag of FDI Linkage	*Excluding Top/Bottom 1%*	*Including Control for Competition*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Service FDI Linkage$_{t-2}$	0.153***	0.105**	0.135**	0.196***		0.069*	0.142**
	(0.050)	(0.053)	(0.054)	(0.063)		(0.035)	(0.060)
Service FDI Linkage$_{t-3}$					0.137**		
					(0.060)		
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Manufacturing and Mining FDI Linkag	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	No
Number of Observations	38185	38185	34852	34852	31759	37467	38185
R-Squared	0.43	0.03	0.05	0.05	0.03	0.03	0.02

Notes: Robust standard errors clustered at the plant level in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% confidence levels, respectively. Plant controls include exporter, FDI, and size dummies. The specification in Column 1 includes also growth in each of six inputs: skilled labor, unskilled labor, electricity, services, materials, and capital. The specification in Column 7 includes the normalized Herfindahl index instead of industry-year fixed effects.

Table 4: Effect of FDI in Services on Plant TFP Growth Excluding Industries

	Dependent Variable: Plant TFP Growth (Levinsohn and Petrin (2003))								
	Excluding Food (ISIC 31)	*Excluding Textiles Apparel (ISIC 32)*	*Excluding Wood Furniture (ISIC 33)*	*Excluding Paper Printing (ISIC 34)*	*Excluding Chemicals (ISIC 35)*	*Excluding Nonmet. Minerals (ISIC 36)*	*Excluding Basic Metals (ISIC 37)*	*Excluding Machinery (ISIC 38)*	*Excluding Other Manuf. (ISIC 39)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Service FDI Linkage$_{t-2}$	0.155*	0.144**	0.170**	0.178***	0.104*	0.131**	0.147**	0.131**	0.148**
	(0.079)	(0.063)	(0.069)	(0.061)	(0.060)	(0.064)	(0.061)	(0.064)	(0.061)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Manufacturing and Mining FDI Linka	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	25916	32017	34395	35730	33193	31575	37502	31575	37641
R-Squared	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03

Notes: Robust standard errors clustered at the plant level in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% confidence levels, respectively. Plant controls include exporter, FDI, and size dummies. In each column, the 2-digit industry whose name is reported in the column heading is excluded from the estimating sample.

Table 5: Extensions

	Dependent Variable: Plant TFP Growth (Levinsohn and Petrin (2003))			
		Sample of Domestic-Owned Plants		
	(1)	(2)	(3)	(4)
Service FDI Linkage*Differ.$_{t-2}$	0.207**			
	(0.087)			
Service FDI Linkage*Non-Differ.$_{t-2}$	0.110			
	(0.073)			
Service FDI Linkage$_{t-2}$		0.153**		
		(0.061)		
Service FDI Linkage*Small$_{t-2}$			0.221**	0.156*
			(0.088)	(0.091)
Service FDI Linkage*Large$_{t-2}$			0.096	0.145**
			(0.069)	(0.068)
Plant Controls	Yes	Yes	Yes	Yes
Manufacturing and Mining FDI Linkage	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes
Region*Year Fixed Effects	Yes	Yes	Yes	Yes
2-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes
P-value for F-Test of Equality of Coefficients on Service FDI Linkage	0.32		0.20	0.91
Number of Observations	36476	35763	38185	38185
R-Squared	0.03	0.03	0.03	0.03

Notes: Robust standard errors clustered at the plant level in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1% confidence levels, respectively. Plant controls include exporter, FDI, and size dummies. In the specification shown in Column 1 the 3-digit industries classified as differentiated product industries are: Textiles (ISIC 321), Apparel (ISIC 322), Leather Products (ISIC 323), Footwear (ISIC 324), Wood Products (ISIC 331), Furniture (ISIC 332), Rubber Products (ISIC 355), Plastics (ISIC 356), Ceramics (ISIC 361), Glass (ISIC 362), Metal Products (ISIC 381), Non-electrical Machinery (ISIC 383), Transport Equipment (ISIC 384), Professional Equipment (ISIC 384) and Other Manufacturing (ISIC 390). In the specification shown in Column 3 plants whose median employment over their lifetime in the sample is less than 25 employees are considered small while other plants are considered large. The specification in Column 4 uses the same threshold of 25 employees but classifies plants into small and large according to employment in their first year of presence in the sample.

Appendix

A. Sample Details

From 1992 to 2002, the ENIA survey gives each plant a unique identifier that allows us to link plants over time to generate a panel dataset. In 2003, the plant identifier changed. We established a correspondence between the old and the new plant identifier by merging two versions of the 2001 dataset (one including the pre-2003 identifier and one including the post-2003 identifier) according to more than 100 variables. We confirm the correspondence by merging two versions of the 2002 dataset (one including the pre-2003 identifier and one including the post-2003 identifier). Thus, we are able to create a panel of plants from 1992 to 2004. In cases where the correspondence between the old and the new plant identifier was ambiguous, we kept the plant with the old identifier and the plant with the new identifier in the sample as separate plants.

The ENIA survey data is judged to be of high quality and has been widely used in research. Thus, only minor data cleaning procedures are applied. First, we exclude from the analysis plants with missing identifiers, missing output or input variables, or missing industry affiliation. Second, we impute output and inputs to correct for non-reporting by a plant in a single year (occurring in fewer than 30 plant-year observations). Third, we exclude from the analysis plants whose output growth is larger than (smaller than) 400% and those whose output growth ranges between 100% and 300% (-300% and -100%) but is not accompanied by corresponding high (low) growth rates of inputs. The sample includes some plants with discontinuous data over the sample period. For those plants, we consider only the observations across consecutive years for which yearly growth rates can be computed. After applying these data cleaning procedures our final sample consists of 57025 plant-year observations. The distribution of the sample across years and industries is shown in the working paper.

B. Production Function Variables

Output is measured by deflated sales. The output price deflator is based on information on indexes of total sales and indexes of physical production for each 3-digit industry from the Chilean Statistical Institute. Based on the equality total sales=physical production * price, one obtains growth in total sales=growth in output + growth in prices. Using this formula we compute an industry output price deflator using 2002 as the base year. For years 1992-2002, the price deflator is obtained for 3-digit ISIC Rev. 2 industries while for 2003-2004 it is obtained for 3-digit ISIC Rev. 3 industries.

Skilled and unskilled labor are measured by the number of workers in the following occupational categories: (a) skilled: owners, managers, administrative personnel, and specialized production workers, and (b) unskilled: workers directly or indirectly involved in the production process, and home workers.

Materials is measured by deflated materials expenditures. The materials price deflator is based on a weighted average of the aforementioned 3-digit output price deflators where the weights are given by the share that each 3-digit industry's output represents in total manufacturing intermediates used by all 3-digit industries based on an input-output table. For years 1992-2002 [2003-2004], the weights are based on the 1986 [1996] Chilean input-output table.

Electricity is the quantity of electricity bought plus the quantity of electricity generated minus the quantity of electricity sold in thousands of kilowatts.

Services is measured by the deflated sum of expenditures on advertising, banking commissions and interest payments, communications, insurance, legal, technical, and accounting services, licenses and foreign technical assistance, rental payments, transport, other services, and water. The services price deflator is based on GDP deflators for 4 groups of services from the Chilean Central Bank: (i) electricity and water, (ii) transport and communications, (iii) financial services, insurance and business services, and (iv) real estate. We calculate a weighted average of these GDP deflators where the weights are given by the share that each of these 4 groups of services represents in total intermediate expenditures (manufacturing plus services) for each 3-digit industry based on the 1996 Chilean input-output table.

Capital is computed using the perpetual inventory method (PIM). The ENIA survey provides information on four types of capital: buildings, machinery and equipment, transport equipment, and land. For each type of capital we compute net investment flows as the sum of purchases of new capital, purchases of used capital and improvements to capital minus the sales of capital and deflate these by an investment price deflator constructed as the ratio of current gross capital formation to constant gross capital formation (in local currency units) from the World Development Indicators with base year 2002. For each type of capital, the PIM formula $K_{it+1} = (1 - \delta) K_{it} + I_{it}$ is applied, where I_{it} are real net investment flows and δ is a depreciation rate. Since detailed studies of depreciation rates in Chile are unavailable, we use the following rates proposed by Pombo (1999) who studied the same type of capital goods in Colombia: 3% for buildings, 7% for machinery and equipment, and 11.9% for transport equipment. Land is assumed not to depreciate. We also experimented with alternative rates of depreciation but did not find this to make a substantial difference to the final capital stock values nor to our main results. The initial value of the capital stock needed to apply the PIM formula is given by the book value of each of the four types of capital in the first year of plant presence in the sample. Whenever the book value is available only in a latter year, we back out that value until the plant's first year in the sample taking into account the investment price deflator and the corresponding depreciation rate.

Summary statistics for the production variables are shown in Appendix Table A.1 for the final sample and for the estimating sample which includes a smaller number of observations given that we use growth rates and two-period lags.

C. FDI Linkage Measures

The main service FDI linkage measure and the regional service FDI measure are obtained based on the following five steps. Where needed we describe (in italics) the differences in obtaining the regional service FDI linkage measure.

1) For each service sector *k* net FDI inflows *NI* are given by $NI_{kt} = I_{kt}^{FDI} - O_{kt}^{FDI}$, where *I* are sectoral inflows and *O* are outflows for each year *t* between 1974 to 2004, obtained from the Chilean Foreign Investment Committee.

1 regional) FDI outflows are not available at the regional level for each service sector thus the net FDI inflows are simply FDI inflows. Regional FDI inflows are available only from 1989 to 2004 thus this period is what is used for our calculations.

2) Using the PIM formula, we compute an FDI stock S^{FDI} for each service sector *k* in year *t* as $S_{kt}^{FDI} = NI_{kt}^{FDI} + (1-\delta)S_{kt}^{FDI}$, where δ is the depreciation rate assumed to be equal to 5.65%, which is the average of the depreciation rates for the capital goods machinery, buildings, vehicles, and land used in the construction of the capital stock for Chilean manufacturing plants. The initial value of the FDI stock needed to apply the PIM formula is given by the net FDI inflows in 1974 for each service sector *k*. Using these inflows as initial value is reasonable given that FDI inflows into service sectors

prior to 1974 were minor. While FDI stocks are calculated for the 1974-2004 period, only the values for the 1992-2004 period are used in Steps 3 and 5.

2 regional) The initial value of the regional FDI stock needed to apply the PIM formula is given by the regional FDI inflows in 1989 for each service sector k. While regional FDI stocks are calculated for the 1989-2004 period, only the values for the 1992-2004 period are used in Steps 3 and 5.

3) For each service sector *k*, we calculate a measure of FDI penetration *(or regional FDI penetration)* in year *t* as $FDI_{kt} = S_{kt}^{FDI} / GDP_{kt}$, where *GDP* is total sectoral output *(or regional sectoral output)*_obtained from the Chilean Central Bank.

4) For plant *i* the intensity of service usage in year *t* is given by $\alpha_{it}^{k} = spending_{it}^{k} / sales_{it}$ i.e., plant expenditures on services from sector *k* as a ratio to sales.

5) We use FDI penetration from Step 3 and plant intensity of service usage from Step 4 to construct the weighted sum which gives the main service FDI linkage measure as: $FDIsl_{it} = \sum_{k=1}^{K} \alpha_{it}^{k} * FDI_{kt}$, where the *K*=4 services are (1) electricity and water, (2) transport and communications, (3) financial, insurance, and business services, and (4) real estate.

5 regional) To construct the weighted sum which gives the regional service FDI linkage measure, regional FDI penetration from Step 3 is allocated to each plant according to the plant's location. This weighted sum is computed over 3 service sectors (rather than 4) since FDI in real estate is included in the financial, insurance and business services category.

The service FDI linkage measure used in Column 1 of Table 1 is based on 4-digit industry weights obtained as follows. For each 4-digit industry *m* and year *t*, we compute total expenditures in each service sector *k* and total sales by summing across all Chilean plants in that year. We obtain industry *m*'s intensity of usage of services *k* in year *t* as the ratio of total expenditures in service sector *k* by the industry to total sales of the industry. Then we take the average across all years of those ratios to obtain τ_{km} which is 4-digit industry *m*'s intensity of usage of services *k*. We use the FDI penetration from Step 3 above and τ_{km} to construct the weighted sum which gives the service FDI linkage measure used in Column 1 of Table 1 as: $FDIsl\_b_{mt} = \sum_k \tau_{km} * FDIpe_{kt}$.

The manufacturing and mining FDI linkage measures included in our preferred specification based on input-output weights are computed as follows. First, we compute FDI penetration ratios for manufacturing and mining sectors as described in Steps 1 to 3 above for service sectors. Second, for example for manufacturing, we calculate the share that each 4-digit manufacturing industry *j* represents in total intermediate inputs (mining plus manufacturing plus services) τ_{jm} used by a 4-digit manufacturing industry *m* based on the 1996 Chilean input-output table. We interact each manufacturing industry's share with the corresponding manufacturing FDI penetration to obtain the FDI linkage variable as: $FDIl_{mt} = \sum_j \tau_{jm} * FDIpe_{jt}$. The mining FDI linkage measure is obtained analogously.

D. Index Number TFP Growth Measure

In Column 4 of Table 3 we use a plant TFP growth measure obtained following a growth accounting index number approach: $d\ln A_{it} = d\ln Y_{it} - \sum_{m=1}^{6} (\frac{s_{t-1}^m + s_t^m}{2}) * d\ln X_{it}^m$, where $d\ln Y_{it}$ is output growth, $d\ln X_{it}^m$ is growth in input *m* (which can be skilled labor, unskilled labor, electricity, services, materials, or capital), and s_{it}^{m} is the share of expenditures in input *m* in total revenues of plant *i* in year *t*. This index number approach assumes perfect competition and constant returns to scale, thus for each plant the average share of capital is equal to 1 minus the average shares of the other 5 inputs. Also, note that we exclude from the calculation of these average shares plants whose input shares exceed 1. We experimented with using median input shares based on all plants instead of average shares and obtained similar results.

Chapter 3: Improved TFP Estimates and Their Responsiveness to Assessing the Effects of Trade Competition

Abstract

Many studies find a positive effect of import competition on firm total factor productivity (TFP) estimates. In this chapter we contribute to the literature in two ways. First, we make use of our dataset on Chilean firms and their products to compute improved TFP estimates and analyze whether these provide the same answer. Second, we use transport costs as a measure of import competition which we argue avoids the problems of endogeneity. Our results suggest that import competition has a positive effect across all TFP measures. Better performing firms tend to benefit more. Import competition from China has a negative effect due to temporary efficiency losses as firms adjust production to face competition.

Keywords: total factor productivity, import competition, transport costs, plant-level data, Chile

JEL Classification Codes: D24, F14, L6

1. Introduction

Several studies find a positive impact of import competition on *traditional* total factor productivity (TFP) measures (Pavcnik, 2002, Fernandes, 2007, De Loecker, 2007 among many others).[33] By contrast, in political discourse specifically import competition from China is perceived as a potential threat to producers in other emerging economies. Moreover, it is well established that firms within any economy are very diverse in terms of their performance (Foster et al., 1998); therefore, positive impacts *on average* may actually mask negative effects for small and more vulnerable firms. Such differential impacts are important to take into account for the design of policies aimed at supporting businesses in emerging economies. Therefore, the first objective of this chapter is precisely to assess the heterogeneous impacts of import competition, including that from China, on firm TFP.

The fact that our variable of interest is TFP adds an important challenge to the analysis. With the only exception of the basic definition of productivity – output per unit input – there is some confusion as to what TFP ideally measures and, more importantly, the lack of detailed data on firms and the products they produce introduces a series of biases in empirical analysis. Doubtless, the attempt to fully capture the complexities of a firm's production with existing data so as to recover actual TFP is impossible to achieve. However, the availability of data on firm products as well as firm output prices and output quantities allows obtaining somewhat improved TFP measures as specified below. It is important to see how *traditional* TFP estimates perform if compared to improved measures because it helps evaluate findings of the large literature that relies on those traditional TFP estimates. The second objective of our analysis is, therefore, to

[33] Tybout (2000) provides a review of the literature.

compare results using both those and improved TFP estimates when applied to the specific question outlined above: the impact of import competition distinguishing specifically the effects of Chinese competition and differences in outcomes depending on firms' distances to the productivity frontier.

In this study we focus on two very specific shortcomings of traditional TFP measures: the fact that (1) they cannot avoid problems of mismeasurement that arise whenever firms change their production processes as new products are adopted or existing ones are dropped and (2) these measures are obtained using industry-level output deflators. We do not address the estimation technique based on which TFP estimates are derived but follow the methodology proposed by Levinsohn and Petrin (2003) due to its large popularity in empirical research (e.g. Alvarez, 2007, Javorcik and Spatareanu, 2008, Girma et al., 2007).[34] Using a rich dataset of Chilean manufacturing firms and their products for the period 1996 – 2003 we compute TFP measures controlling for both shortcomings specified above. In our analysis we use industry-level information on transport costs from China and all other trade partners of Chile as an exogenous measure of import competition. The results suggest that while there is a difference in magnitudes, the general impact of import competition is positive and significant for all types of TFP measures. Also, the evidence shows that the effect of import competition from China on firm TFP is negative regardless of what measure of TFP is used. The latter effect is shown to be the result of temporary efficiency losses of firms as they adjust production following the adoption of new products to face import competition from China. In terms of heterogeneity, large and more productive firms tend

[34] One of the advantages of their methodology that explains some of its popularity is that it takes care of the endogeneity of inputs with respect to TFP.

to benefit more from import competition and suffer less from Chinese import competition.

TFP is in essence a measure of disembodied technical change and positive spillovers. A first step to obtain firm TFP measures consists in defining a production function that stipulates the relation between physical inputs and outputs *both measured in quality-adjusted units.* Since data on quality-adjusted output units is rarely available, researchers have used revenue-based output measures deflated by industry-level price indices to proxy for physical output. However, the use of industry-level prices and firm revenues only allows retrieving information on output if markets are perfectly competitive so that industry and firm prices are equal (Katayama et al., 2009).[35] Moreover, the recent analysis of firms and their products has highlighted other aspects of firm production that complicate the measurement of TFP (Bernard et al., 2005). We will focus on one central aspect only: the mismeasurement problem that arises for TFP estimates as firms change their production technologies when they drop or add products.[36] We thus obtain in addition to traditional TFP estimates (S1) [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations] that correspond to what most of the literature on TFP has used as well as TFP estimates (S2) [TFP^{S2}: $p_i = p_{industry,year}$; for continued-product firm-year observations] and (S3) [TFP^{S3}: $p_i = p_{firm,year}$; for continued-product firm-year observations].

Analyzing the question of whether import competition affects firm TFP poses several challenges beyond concerns about the dependent variable itself. While import

[35] Otherwise, productivity measures contain mark-ups of price-setting firms. But firms with larger profits are not necessarily more productive (Foster et al., 2007).

[36] Another complication is the fact that many firms produce more than one product and that, if considered as single-product firms, possible economies of scope and/or cost synergies are not taken into account (De Loecker, 2007). The concern seems, however, negligible at least in the case of our specific dataset as is discussed in section 2.

competition is expected to have a significant impact on TFP (e.g., Aghion et al., 2005, 2006), it is equally possible that TFP affects import competition.[37] In order to address reverse causality we rely on an effective trade barrier measure - transport costs - which captures differences in import competition across 4-digit ISIC industries that are exogenous to firm TFP. Another advantage of using trade cost measures is that these allow measuring import competition faced by Chilean producers from any country. We compute two separate import competition measures based on trade costs for Chinese exports to Chile and on trade costs for exporters from all other countries to distinguish overall effects from those specifically caused by Chinese import competition. In order to ensure that our estimates of the effect of import competition on firm-level TFP do not pick up the effects of foreign direct investment or internal competition we include these measures as well as variables that capture firm-specific characteristics as controls. Moreover, we ensure that our analysis does not erroneously compare the levels of TFP for firms in different industries by including 3-digit-ISIC industry-year fixed effects in addition to year fixed effects in our regressions. We use two methods of estimation for our main specification: ordinary least squares and quantile regressions. The latter serves to inform about the heterogeneous impacts of import competition on differently performing firms.

We find a positive impact of import competition from all countries other than China on firm-level TFP in Chile; this confirms the findings of previous studies. If we compare results of measures S2 [$TFP^{S2}: p_i = p_{industry,year}$; for continued-product firm-year observations] and S3 [$TFP^{3}: p_i = p_{firm,year}$; for continued-product firm-year observations] with the measure S1 [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations] most of the

[37] One possibility for such reverse causality is that firms in industries with lower productivity may lobby policy-makers and obtain trade protection for their industries.

existing research relies on, our findings suggest that while their magnitudes differ the estimated impacts of import competition are qualitatively similar for all TFP measures. Our results also show that more efficient firms benefit more from import competition. The significant negative impact of Chinese import competition on TFP in Chile may be due to temporary efficiency losses as firms adjust their production either by improving existing products as discussed in Chapter 4 and after the adoption of new products as discussed in this chapter. There are, however, several possible caveats to our findings as will be discussed in the conclusion.

This chapter relates most closely to three strands of the literature. Concerns about the measurement of TFP in the absence of firm output data and prices are raised by several studies including among others Griliches and Klette (1996), Jaumandreu and Mairesse (2005), and Katayama et al. (2009). The former two studies focus specifically on production function estimates themselves and propose alternative estimation techniques when data on output and prices are not available. A different approach is taken by a few other studies, including Eslava et al. (2004, 2005a, 2005b). They make use of firm-level price and output data to remove biases introduced by the use of firm output data and prices. These studies do not address mismeasurement problems that arise whenever firms add and/or drop products changing their production functions. Bernard et al. (2005) provide an interesting theoretical model to illustrate how product switching introduces undetermined biases which, ultimately, depends on underlying changes to production functions. Another source of bias arises for multi-product firms (De Loecker, 2007). Furthermore, the chapter relates to the literature that has examined the impacts of import competition on TFP. A comprehensive overview of the literature is provided by

Tybout (2000).[38] Our analysis is most similar to De Loecker (2007) who analyses impacts of import competition on TFP comparing alternative estimates. His analysis is, however, set in a very different context, the Belgian textile industry, and implements a methodology to deal with missing firm price information which is available for our analysis. Finally, regarding the heterogeneous impacts of competition on firms, our work is related to several papers including Schor (2004), Yasar and Morrison Paul (2007), Konings and Vandenbussche (2008), Lileeva and Trefler (2007) and Iacovone (2009) as well as Aghion et al. (2005, 2006). Similarly to Yasar and Morrison (2007) we use quantile regression analysis to study heterogeneous impacts. None of these papers analyze the question of the measurement of TFP and its possible impact on findings.

Following the introduction this chapter proceeds as follows, in section 2 we review the basic notion of TFP, its traditional measurement and three main shortcomings of traditional TFP estimates. This is followed (in section 3) by a discussion of the empirical framework adopted covering data, TFP measures, trade costs and the regression framework itself. We next discuss results in section 4 and conclude (section 5).

2. Total Factor Productivity

2.1 Definition

The only aspect about TFP that is straightforward is its definition. It is simply "output per unit input" (Hulten, 2000) or, alternatively, the "ratio of a volume measure of output to a volume measure of input use" (OECD, 2001).[39] TFP is interesting as a

[38] More recent studies include Pavcnik (2002) and Fernandes (2007) among many others.

[39] Note that while this discussion will focus specifically on total factor productivity, much of it will be equally relevant for another popular measure of productivity, labour productivity. The difference between both concepts is that the latter only controls for labour inputs.

relative rather than an absolute measure either to measure performance relative to other firms or relative to the firm's past performance. Defining TFP requires defining the firm's production function, that is, specifying how inputs, *X*, are combined to generate output, *Y*:[40]

$$Y_{it} = A_{it} F_{it}(X_{it}) \qquad (1)$$

where *F* specifies the production technology and *A* denotes TFP of firm *i* at time *t.* Since *A* cannot commonly be observed in the data[41] it is obtained as a residual. Once a functional form is selected for F(.), a large variety of estimation techniques can be used to estimate Equation (1) and obtain the residual *A*. Discussing each of these techniques in detail is beyond the scope of this chapter. We will simply note that the main difference between the most common methods is how the term $F_{it}(X_{it})$, is obtained. Van Biesebroeck (2006, 2007) discusses the distinct approaches as they rely on different underlying assumptions.[42]

2.2 Interpretation

It is worth reflecting on what A_i will ideally measure since the empirical literature tends to be very concise on this topic and provide different explanations (Carlaw and Lipsey, 2004).[43] We will review three common interpretations: (i) technological change, (ii) spillovers, and (iii) efficiency improvements. The first

[40] It should be mentioned that this representation introduces a limitation in that is suggests that firms produce a single output. We will discuss further below the issue of multiple outputs.

[41] A possible way to measure directly a 'quantity' related to TFP could be to have a measure of the number of defective units produced by a plant (see e.g. Sutton, 2004). This is, however, an unsatisfying measure since it does not capture all the technological change captured by productivity.

[42] Van Biesebroeck (2006) shows that, in practice, when TFP growth and levels measures obtained using these diverse methods are applied to answer specific questions they generally tend to produce similar results. This does not, however, mean that any estimation technique is just as good to use. Methods matter significantly for any researcher interested in production function coefficient estimates themselves. Furthermore, as noted in a companion paper, each method may be appropriate for specific datasets depending on their characteristics (Van Biesebroeck, 2007).

[43] The topic is discussed in the OECD Productivity Manual (2001) for aggregate TFP measures at the national or industry level.

explanation interprets an increase in A_{it} as equivalent to the adoption of a new production technique that allows producing a larger number of physical output with the same inputs this year compared to last year. It is important to bear in mind that A_{it} only captures disembodied technological change (OECD, 2001). It does not include improvements in production processes brought about by the purchase of new technologically more advanced machines. The reason for this is that TFP growth ideally measures output increases *net of input increases*. The type of technological change accounted for is free knowledge that allows achieving more output for given inputs.[44] The empirical research supports this story partly as the relationship between innovation and TFP is found to exist; yet it explains only a little share of TFP growth (see OECD, 2001).[45] This suggests that TFP should not be the only measure of interest for any exercise aiming to analyze technological change.[46]

Second, a related idea that comes to mind when thinking about A_{it} as capturing free disembodied knowledge is that of *spillovers*. Spillovers are externalities from economic activities on other actors that are not involved. In this context the idea is that the firm makes use of knowledge developed elsewhere at no charge. This is very close to the concept of disembodied knowledge but it does not include the possibility that the firm itself may find novel knowledge and in that way increase its own TFP. Yet most knowledge contributing to improve production techniques is likely to have cost an

[44] Note that while this is true in theory it is not necessarily the case empirically. Information on input quantities is frequently unavailable, so researchers use data on input expenditures deflated by input price deflators. If these do not take into account input quality improvements, then these will be included in TFP measures as long as price increases do not account for increased quality. This would include some embodied technological change but only under this specific condition (depending on market conditions in inputs markets that do not allow those offering better inputs to get full returns to their better inputs). This is discussed in further detail in Chapter 2.
[45] However, this may to some extent also be due to shortcomings in measurement of TFP (as will be discussed below).
[46] Note this does not in any way diminish the value of TFP measures since, if data are available, one can recover information on embodied technological change independently of the TFP measure since the researcher will know about firm purchases of higher quality inputs.

investment from some other economic agent. Therefore, frequently free knowledge is likely to benefit the firm as some kind of positive externality from other producers.[47]

Third, another possible interpretation may be to suggest that TFP measures production efficiency improvements as firms do not use technologies and input resources optimally (Diewert and Lawrence, 1999). While TFP measures may, in practice, capture such efficiency effects, it is generally difficult to reconcile with theory since production functions supposedly outline output production possibilities given inputs and firms operate at their optimal production level.[48] Among the many other aspects TFP estimates may capture are changes to scale economies, cyclical effects, adjustment costs, and measurement error.

2.3 Measurement Problems: Product-Switchers

Whatever method researchers ultimately choose to obtain TFP estimates, they initially take a potentially more important step specifying a specific production function for firms with specific measures of inputs and outputs. Total factor productivity is defined for a given production technology and output. Products datasets for manufacturing firms in different countries show that while some firms produce one and the same single product during their existence, a large proportion of firms produce more than one product and/or change products during their lifetime (Navarro, 2008, Bernard et al., 2006b, Goldberg et al., 2008). Most production inputs are not fully flexible and

[47] This interpretation is even more relevant in a developing country context and may apply well to discussions on productivity impacts of openness to trade and foreign direct investment (FDI). This is the perspective adopted in Chapter 2 where we deal with the impacts of services FDI on TFP growth. The interpretation given to TFP growth is the idea of positive externalities accruing to domestic producers from improvements in the production of services by foreign producers.

[48] DEA productivity analyses are a notable exception since they recognize the possibility for firms to produce within the technology frontier. This is one of the major advantages of these measures; however, technical complexity, demands on data, and the required underlying assumptions are a less attractive feature (Diewert and Lawrence,1999).

the discontinuation of a product or adoption of a new one will initially be misaligned with production inputs. The case of labour inputs is possibly the most obvious example; it will take time to dismiss employees that are no longer required or find additional employees that are more suitable. This means that specifically in periods when firms add and/or drop products their inputs very unlikely reflect actual inputs into production processes. These estimates are, therefore, likely to include large measurement errors as many firm resources do not adequately reflect production inputs used in the new production context. Therefore, TFP measures during that specific period are not adequate for analysis.[49] Note that this is not to say that possible adjustment costs will be excluded from our measure of TFP as firms learn to produce new and/or improved products. The only problematic aspect here is the initial period of a major production change since it will not reflect production inputs correctly. If we measure TFP in that period it will not adequately inform on production efficiencies since some inputs while paid for by the firm would not even be used. Adjustment costs to new production processes captured will be those that arise during the period where firms "learn" optimal production techniques for new products.

Another problematic issue is that in practice a large share of firms produces more than one product in every period. That creates further problems because producers are likely to have different production technologies for each product and an aggregate production function does not account for that adequately. Bernard et al. (2005) argue

[49] Note that additional problems arise the aim is to have productivity growth estimates. If production technologies differ across narrowly defined products, then *any TFP estimates will capture such differences across production techniques rather than actual improvements in TFP.* It is the difference in production techniques used to manufacture different products that poses a problem here. If a firm were to decide on different products manufactured using the same technique, then it would still be valid to obtain TFP growth estimates as long as output is properly measured. That is, the output measure has to exclude any differences in demand-side aspects across previous and new products such as differences in firm market power affecting prices and, therefore, industry-level output prices.

that “(e)ven if firm-specific data on prices or information on physical quantities of output is available, measured firm TFP is biased because it captures both true TFP differences across firms as well as differences across products in production technique” (Bernard et al., 2005, p. 6). Moreover, if TFP is estimated for all products of multi-product firms using an aggregate production function, this is problematic since it ignores economies of scope that plants may achieve by producing more than one output (de Locker, 2007).

Several aspects suggest that in practice, if we account for firm prices, the multi-product plant problem is somewhat attenuated. First, our dataset is not at the firm level but at the plant level, therefore, it describes all goods produced in a given physical location. While this might still include a variety of outputs it does exclude the possibility that we are including output of a conglomerate of plants. Second, and more importantly, the data shows that the production of multi-product firms is very much centered on their main products – which usually account for a large share in sales – and many of the additional products are from the same 4-digit ISIC industry. This suggests that other products are likely to be by-products of the same production process.

2.4 Measurement Problems: Lack of Firm-Level Prices

A firm’s production function as specified in (1) relates physical units of output to physical units of inputs. Such information is, however, rarely available. For that reason, most of the literature has relied on TFP estimates that measure units of output and inputs using information about the value of outputs (through either value-added or sales) and the value of inputs (through expenditures on inputs) jointly with industry-level price deflators. (There is, however, a notable exception for inputs; labour inputs can generally be measured in units – i.e. counting the number of employees – and in our specific case we also have a quantitative measure of electricity inputs.[50]) Focusing on output measures, if industry prices p_I are equal to firm prices p_i, then firm physical output can be measured using information on firm sales (p_iY_i) and on prices (p_i) since the ratio of firm sales to prices is equal to output quantity Y_i. However, this will only be obtained under the assumption of perfectly competitive markets where all firms are price-takers (and, therefore, prices are the same for all producers in the industry).[51] Micro-level evidence has uncovered that there is a lot of price dispersion even within much disaggregated product categories (Abbott, 1988, Abbott, 1992, Dunne and Roberts, 1992). This dispersion is, at least to some extent, due to differences in market power across firms (Abbott, 1992). Therefore, we know that firms most often operate in imperfectly competitive markets producing differentiated products and some firms – those with larger market power – charge higher prices than others (i.e., they are price-setters).[52] It is, therefore, impossible to recover output with this procedure without introducing biases in the output measure and, as a result, in the TFP measures.

Firms with strong market power will charge prices that are higher than the industry average. If real output is obtained deflating sales revenues by the industry price index, then these firms will have a higher measured output than their true output. TFP estimates will therefore be higher for these producers relative to firms with less market power. Foster et al. (2007) provide empirical evidence in support of this hypothesis: firms with higher profits – those with some price-setting power – tend to be attributed

[50] Detail on inputs and outputs are provided in the data appendix.
[51] As Martin (2005) points out, this is actually inconsistent with variation in TFP across firms - which is the main focus of our interest – since plants managing to produce output for same inputs should over time successfully impose themselves on the market and ensure that less efficient producers exit.
[52] Note that a second reason why firms may charge higher prices is that they may produce better products compared to other firms. We will discuss that aspect below.

higher TFP measures than is the case when traditional revenue-based measures are used. This aspect is particularly relevant for TFP measures in levels.[53]

2.5 Measurement Problems: Product Quality

It is important to note that deflating revenue by firm-specific prices does not account for potential product quality improvements of firms' products over time. As discussed in Chapter 4 and in a large trade literature (e.g., Fontagné and Freudenberg, 1997; Schott, 2008; Kiyota, 2008) product prices are an indicator of product quality: prices reflect partly the size of the firm mark-up and partly demand conditions. To account for quality, the ideal firm-level price measure would require having hedonic products measures (OECD, 2001).[54] Otherwise all price increases are excluded – and this would introduce serious biases. The following illustrates the issue at hand: Consider the following Cobb-Douglas production function in logarithms and first-differences for plant *i* in industry *j* at time *t*:

$$d \ln Y_{it}^{j} = d \ln A_{it}^{j} + \sum_{m=1}^{M} \eta_{m}^{j} * d \ln X^{m}{}_{it}^{j} \qquad (2)$$

For each plant, output is measured by nominal sales deflated by a firm-specific output price deflator. Improvements in the quality of output are not captured by firm-specific output price deflators since we lack information on product characteristics. Following Griliches and Lichtenberg (1984), we can define a discrepancy d_{it}^{j} between

[53] Similar issues may arise on the input side since with the exception of workers and some selected inputs (depending on the specific firm dataset used), information on the input quantities consumed is scarce and, therefore, expenditure in inputs deflated by industry prices are used. The possibility of deviations of industry prices from firm-specific prices in this case is to do with firms' potential possibilities to influence input markets. The topic is discussed in further detail by Katayama et al. (2009).

[54] The method consists in defining firm's outputs over time as combinations of their characteristics so that, for instance, a new computer does not represent an entirely new product but rather a new combination of previous products' characteristics. Quality-adjusted price indices can be obtained by regressing product prices on a set of characteristics. But such procedures would require specific information on product characteristics that is generally unavailable.

the change in the available output price deflator, $d\ln py_{it}^{j}$, and the change in the true quality-adjusted output price deflator $d\ln py^{*j}_{it}$: $d\ln py_{it}^{j} = d\ln py^{*j}_{it} + d_{it}^{j}$. If the change in nominal sales is correctly measured ($d\ln NY_{it}^{j} = d\ln NY^{*j}_{it}$), then growth in output in (2) is calculated as $d\ln Y_{it}^{j} = d\ln NY_{it}^{j} - d\ln py_{it}^{j}$. However, growth in true output is given by $d\ln Y^{*j}_{it} = d\ln NY_{it}^{j} - d\ln p\acute{y}^{*j}_{it}$. Thus, $d\ln Y^{*j}_{it} - d\ln Y_{it}^{j} = -d\ln py^{*j}_{it} - (-d\ln py_{it}^{j}) = d_{it}^{j}$. Making the simplifying assumption that inputs are correctly measured, (2) can be rewritten in true growth rates as:[55]

$$d\ln Y_{it}^{j} = d\ln A^{*j}_{it} + \sum_{m=1}^{5} \eta_{m}^{j} * d\ln X^{m\,j}_{it} + d_{it}^{j} \qquad (3)$$

where $d\ln A^{*j}_{it}$ is actual TFP growth. This implies that measured TFP growth $d\ln A_{it}^{j}$ based on (2) deviates from true TFP growth by the discrepancy in the change of the output deflator: $d\ln A_{it}^{j} = d\ln A^{*j}_{it} + d_{it}^{j}$. As Griliches and Lichtenberg (1984) state, this equality is a definitional relationship between measured TFP growth and true TFP growth. This final shortcoming remains a problem for our improved TFP estimates since we do not have hedonic price indices.

3. Empirical Framework

3.1 Data

The main dataset used in our analysis is the Encuesta Nacional Industrial Annual (ENIA), which is the annual manufacturing survey of Chilean plants with more than 10 employees. The dataset is an unbalanced panel capturing plant entry and exit covering

[55] This is a strong assumption given the problems associated with the measurement of intermediates by deflated expenditures in the absence of data on physical quantities of intermediates, as discussed earlier.

the 1997-2003 period and including an average of 2894 plants per year[56] classified into 4-digit ISIC revision 2 industries.[57] More details on how the dataset was obtained are given in Chapter 2. The ENIA survey collects plant-level information on sales, employment, raw materials, investments (buildings, machinery and equipment, transportation, and land) which are used to construct output and inputs for the production functions. We show how these are obtained below while information on the variables included is discussed in the data appendix.

Table 6 shows descriptive statistics for our main regression variables as well as production function inputs. Furthermore, we make use of a companion dataset on the products of firms that provides information on overall sales by product and quantities as well as information on all the products produced by a firm. Most importantly for our purposes, that dataset provides us with information on (i) unit prices charged for firms' products, (ii) the number of products produced, and (iii) whether firms change the products they produce or not. More information on the dataset is provided in Chapter 4.

3.2 Obtaining TFP Estimates

The estimation of TFP is an increasingly complex topic of key importance with an important debate on the question of estimation procedures (Van Biesebroeck, 2007, Katayama et al., 2009) It is beyond the scope of this chapter to discuss these questions in detail since our focus is on addressing the two shortcomings of measures identified above - the problem of product switching and the use of firm-specific price deflators – and compare TFP measures correcting for these shortcomings with standard TFP

56 The average number of plants in any year is computed based on our baseline regression sample S1.

[57] The ENIA dataset has been widely used in research e.g., by Pavcnik (2002), Alvarez (2007), and Bergoeing and Repetto (2006). While the dataset provides information by plant according to Pavcnik (2002) more than 90% percent of Chilean firms during the 1979-1986 period were single-plant firms. Thus plant data corresponds to a large extent to firm data.

measures. In order to relate to the existing literature, we will use TFP estimates derived based on the popular method proposed by Levinsohn and Petrin (2003).[58] Production technologies are obtained based on estimations assuming, generally, a common production technology for firms of the same more or less broadly defined industry (in our case we obtain these measures at the 2-digit ISIC industry level). A major contribution of these methods is to address the endogeneity problem of simple OLS production function estimates.[59]

First, in order to address the problem posed by product-switching and multi-product firms, our approach is to select a sub-sample including only firm-year observations when firms neither add nor drop products. We could be even more rigorous and exclude all multi-product firms. However, this would create another problem as it would significantly reduce the sample size and, therefore, increase potential biases. Considering the factors that attenuate possible problems (as discussed in section 2) due to the inclusion of multi-product plants we, therefore, decide not to drop them for any estimates.

Second, the problem of industry-price deflators to obtain output can be addressed using firm-price deflators following Eslava et al. (2004, 2005a, 2005b).[60] This approach

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[58] Another popular method is the index number approach, applied and discussed in more detail in Appendix A of Chapter 5, has the advantage of obtaining productivity measures that do not require estimation, it allows each firm to have its own production technique but requires, in turn, that input markets are competitive so that the return to each input equals its marginal product. In that case, the return to each type of input – such as wages paid to labour - as a share of overall production costs is equivalent to marginal products and can, therefore, be measured using output revenue and input expenditure information. Moreover, in practice, the method often requires assuming constant returns to scale because the rental price of capital is commonly unavailable. Assuming constant returns to scale allows obtaining the share of capital as what is left over after the shares of other inputs are discounted.

[59] More detail on production methods is given in Olley and Pakes (1996) and, for extensions, in Levinsohn and Petrin (2003) and Ackerberg et al. (2006).

[60] Important alternative approaches are proposed by Katayama et al. (2009), Griliches and Klette (1996) and Gorodnichenko (2005). The way these studies propose to address the problem of firm price-taking behavior is to model firm product demand. Moreover, output biases are corrected for by either using revenue output measures deflated by firm prices (Eslava et al., 2004, 2005a, 2005b) or physical output

effectively ignores possible quality improvements reflected in price increases. The issue cannot be adequately addressed in the absence of hedonic price indices. The fact that only two studies (Foster et al, 2007 and Syverson, 2004) use physical output quantities for the estimation of TFP highlights another complication: firms' products are highly heterogeneous and differ in quality. The two studies can only obtain meaningful results for a selection of producers – those producing homogeneous products with little scope for quality differences. While it is possible to compare physical output of tons of cement it is not clear how units of cars can be compared. This is because there is little scope for improvements when it comes to cement, but there may be huge differences between a given quantity of cars produced by one firm versus another firm. What is important is not the fact that firms do not charge differential prices for those products – that is not essential since the price level does not enter the computations at all – but that output quantities are comparable. Otherwise, it is absolutely important to include information on prices since they are the only element that allows distinguishing among a heterogeneous set of goods in terms of inherent quality differences. As an example, the number of high-quality cars cannot be compared to that of low-quality cars. However, since researchers are still interested to compare producers of these cars and obtain their TFP, the only option is to use price information jointly with output quantities trying to properly deflate price inflation.

Our procedure thus consists in obtaining production function estimates following the method of Levinsohn and Petrin (2003) for each 2-digit industry. We will obtain three TFP estimates S1 [$p_i = p_{industry\text{-}year}$; for all firm-year observations], S2 [$p_i = p_{industry\text{-}}$

quantities (Foster et al., 2007, Syverson, 2004) or, in the absence of data on prices, correcting for demand side aspects (Van Biesebroeck, 2007). It is important to mention that Eslava et al. (2004, 2005a, 2005b) use demand estimations to obtain their TFP. However, they do not do so to correct for output biases (they correct for those by use of firm-specific prices) but in order to use those results as instruments for endogenous production inputs.

$_{year}$; for all continued product firm-year observations] and S3 [$p_i = p_{plant\text{-}year}$, for all continued product firm-year observations]. Note that we obtain firm-specific output deflators calculated as a weighted average of firm product price changes with weights given by the sales share of products in total firm sales following the method proposed by Eslava et al. (2004). More detail on how those deflators are computed is provided in the data appendix. Production function estimates are provided in the appendix. Table 6 provides, in addition, descriptive statistics for these three sets of TFP estimates showing that for the variables of interest for this study the characteristics of the 3 samples (corresponding to each of the TFP estimates) are fairly similar allowing comparisons across different samples possible.[61]

3.3 Trade Costs

Our measure of transport costs is based on detailed information provided by the Latin American Integration Association (ALADI) on freight costs excluding insurance costs and the free on board customs value (fob) of Chilean imports for each 8-digit Harmonized System (HS) code, exporting country, and year from 1997 to 2003. First, we compute for 8-digit HS code *i* from exporting country *c* in year *t* freight rates as the ratio of freight costs ($freight_{ict}$) to the fob value of imports (fob_{ict}): $TC_{ict} = freight_{ict} / fob_{ict}$. Second, we aggregate these freight rates from the 8-digit HS code, exporting country, and year level to the 4-digit ISIC (revision 2) and year level using (i) a concordance between 8-digit HS and 4-digit ISIC codes and (ii) weights given by Chile's 8-digit HS fob imports from each exporting country and year as a ratio to Chile's total imports in the corresponding 4-digit ISIC code in that year. More details

[61] We note, however, that there is a slight decrease in the share of exporters and output from samples S1 to S3.

on the construction of the freight costs measure are provided in Chapter 4. We will refer to our measure hereafter as ‘transport costs measure’.

Table 7 illustrates the substantial variation in our transport costs measure over time and across a selection of 4-digit industries. Since some countries may not export a product to Chile due to prohibitive transport costs, our measure is a lower bound for transport costs accounting only for those of the exports that actually occur (Hummels, 2001). However, since this feature of our measure is common to all products, it does not impair our analysis which focuses on the relative differences in the relative rather than the absolute magnitude of transport costs across industries and time.

Transport costs proxy adequately for the exposure to import competition of plants in Chilean industries during the sample period for four reasons. First, export choices are to some extent driven by freight costs. For example, within disaggregate product categories, exporters with the lowest freight rates are shown to have the largest import shares based on data for the U.S., New Zealand, Argentina, Brazil, Chile, Paraguay, and Uruguay (Hummels, 2001). Second, transport costs can play an important role in “altering patterns of trade across goods and partners” due to their size and variability across trade partners (Hummels et al., 2008). Third, transport costs represent currently a greater share of trade costs than tariffs for most countries including Chile (Anderson and Wincoop, 2004).[62] Fourth, our measure excludes insurance costs and, therefore, does not face related concerns of endogeneity.

[62] Moreover, the most usual measure of trade barriers - tariffs - is not informative in the Chilean context due to the uniform tariff structure across industries in place since the 1980s’ trade liberalization (Chumacero et al., 2004). Chile’s entry into preferential trade agreements with various countries and regions since the 1990s introduced a complex set of product- and country-specific exceptions to that uniform tariff structure which could provide useful variation for our analysis. However, such exceptions are subject to political economy pressures and are likely to be endogenous to product quality in an industry.

Finally, note that our measure of transport costs is obtained at the 4-digit ISIC revision 2 level. Each transport cost measure is linked to the plant's main product industry in all cases where firms produce more than one product. We believe that this is a better measure of the level of import competition faced by the firm than a weighted average of trade costs for all products of the firm. The latter may, however, provide for an interesting robustness check.

3.4 Regression Framework

The basic specification which will allow us to examine TFP responses to changes in the transport costs faced by each plant's main product is given by:

$$\log TFP_{it} = \overline{\beta}_{TC1} * TCchina_{it-1}^{k4} + \overline{\beta}_{TC2} * TCall_{it-1}^{k4} + \gamma * X_{it} + I^{m3} * I_t + \varepsilon_{it}, \qquad (4)$$

where $\log TFP_{it}$ is the log of TFP of plant *i* in year *t*, $TCchina_{it-1}^{k4}$ and $TCall_{it-1}^{k4}$ are transport costs for imports from China and for imports from all other countries, respectively for the 4-digit industry *k4* to which the firm's main product belongs, X_{it} is a vector of controls to be specified below,, $I^{m3} * I_t$ are 3-digit industry *m3*-year fixed effects, and ε_{it} is an independent and identically distributed (i.i.d.) residual. We will now discuss the different issues that arise from this specification.

First, it is important to discuss the possibility of reserve causality: firm TFP may have an impact on import competition. One way that such reverse causality could materialize is political lobbying of firms against trade liberalization. We can, however, disregard this possible channel as our measure of import competition is a measure of "external" transport costs incurred by imports from the exporting country until the arrival to Chilean ports and thus are not affected by Chilean trade policy decisions. Moreover, even if Chilean policy-makers attempted to reduce trade-related insurance costs or to improve the quality of domestic ports, those actions would not be captured by our measure of transport costs the more so since it excludes insurance costs.

However, we can identify two possible ways how TFP may affect transport costs. First, if some firms improve their TFP strongly, then some producers who previously exported to Chile may decide to stop their product exports to Chile. This will affect our competition measures if the impact is such that some countries' industries no longer export to Chile because they will no longer enter transport cost calculations. Our measure of transport costs would only increase, however, to reflect this decline in competition if those countries had lower transport costs. It is likely that it would be producers in countries exporting smaller quantities to Chile that would stop exporting and that exporting smaller quantities would be linked to higher transport costs. Thus, there is a possibility that our measure of transport costs may decrease as a result of TFP improvements. This issue is relevant for our analysis to the extent that only half of Chile's import relationships at the country-4-digit industry level last the entire sample period. However, since our measure is a weighted average of transport costs across all countries, the exclusion of a country is unlikely to affect it unless it is one of the largest trading partners. Our data shows that few of the large trading partners stop exporting any 4-digit categories to Chile during the sample period.[63] Nonetheless, we consider this issue in our robustness checks and find that our results are not driven by this potential reverse causality channel. The second possibility is that TFP improvements in Chile could motivate producers in certain countries to export smaller quantities to Chile. This would result in higher freight rates if exporters no longer benefit from economies of scale in the transportation of their products. In this case, TFP improvements would lead

[63] Considering the top 10 exporting countries to Chile for each 4-digit industry, 4,400 out of 4,764 observations (94%) correspond to relationships that last the entire sample period.

to weaker import competition and actually work against the finding of a positive effect of import competition on TFP improvements. However, the importance of such scale economies in affecting freight rates is unclear. These two possibilities describe possible effects of TFP improvements on transport costs. To help mitigate these potential biases in our estimates of β_{TC1} and β_{TC2}, we follow Bernard et al. (2006a) and include a one-year lag in both variables $TCchina$ and $TCall$.

Second, direct comparisons of TFP in levels are complicated since this would compare firms employing potentially very different production methods. Therefore, we include industry-year fixed effects so as to account for such differences (Van Biesebroeck, 2006). Third, foreign companies have two options to sell their products in the local market: the first option is to export products to Chile and the second is to set up a plant in Chile and produce there. As firms may decide between these options depending on their costs, high trade costs may render the FDI option more tempting whereas low trade costs may have the opposite effect. Thus, competition through FDI may be correlated with our trade costs measure. We, therefore, include a measure of FDI defined as the share of foreign workers in total workers by 4-digit industry as a control. We also control for several other potentially partly unobserved industry characteristics via the inclusion of 3-digit industry-year fixed effects.

Fourth, in addition to foreign competition, local competition is an equally important element to account for. The degree of local competition may be affected by the extent of import competition and, therefore, may be to some extent correlated with trade costs. To ensure that our import competition measure does not pick up any of these effects we include two controls: the normalized Herfindahl index computed at the 4-digit industry level as an industry-level measure of competition and a measure of firm market shares. Technological differences between industries likely have an impact on their market structure so that the measure of firm market shares is not reliable in cross-sectional comparisons (Sutton, 1996). We, therefore, follow Disney et al. (2003) and use the change in firm market share rather than the level of the firm market share.

Finally, while it is not strictly necessary to our analysis – as trade costs are very unlikely to be correlated with firm characteristics – we include three traditional firm controls – dummies for firm size and for foreign-ownership status and for exporter firms to be absolutely certain none of these characteristics are taken up by our trade costs measure. Indeed, as our results reported below will show that their inclusion does not significantly affect our results. This confirms our intuition of an unlikely correlation of firm characteristics with our variable of interest, trade costs.

Thus, the full regression that we estimate is the following:

$$\log TFP_{it} = \overline{\beta}_{TC1} * TCchina_{it-1}^{k4} + \overline{\beta}_{TC2} * TCall_{it-1}^{k4} + \varphi * dFDI_{it} + \phi * \Delta MSHARE_{it} + \lambda * dX_{it} + \chi * dSIZE_{it} + \kappa * herfindahl_{It} + \pi * FDI_{It} + I^{m3} * I_t + \varepsilon_{it}, \quad (5)$$

where $dFDI_{it}$ is a dummy indicating whether firm *i* at time *t* is foreign-owned or not, $\Delta MSHARE_{it}$ is the change in firm *i*'s market share between *t* and *t-1*. dX_{it} is a dummy for exporter status of firm *i* at time *t* and $dSIZE_{it}$ denotes firm size dummies.[64] Industry controls included are FDI_{It} – a measure of the share in total 4-digit ISIC industry employment of foreign-owned companies - and $herfindahl_{It}$ – the normalized Herfindahl index measured at the 4-digit ISIC industry level at time *t.*

[64] Three size categories are considered: small plants (1-50 employees), medium plants (50-200 employees), and large plants (200 or more employees). But the results are robust to the use of alternative size categories.

4. Results

4.1 Main Findings

Panel 1 of Table 3 reports the results of our baseline OLS regression for (5) using TFP measure S1 [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations]. Note that in this as in all other tables we report the coefficient on the negative of trade costs; a higher value of the trade costs measure corresponds to an industry with stronger import competition. We find a positive and significant impact of competition from all countries with the exception of China and a significant negative impact of competition from China on firm TFP. Note that qualitatively the results do not change as we include plant and/or industry controls. Note that the change in the magnitude of the estimates reported in columns (1), (2) and (3), (4) is not due to the inclusion of firm controls but rather to the decrease in sample size as we include the growth in firm market shares between *t* and *t-1*. Panel 2 of Table 3 shows in addition to these OLS estimates results from quantile regressions. Based on the TFP estimates S1 [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations] we find that all firms benefited from foreign import competition. However, there are important differences in terms of magnitudes; less efficient firms tend to improve less as a result of import competition from countries other than China than those with already high TFP. This is intuitive suggesting that firms with better capabilities for innovation (the highest-TFP firms) will be the more so in a position to improve their production processes as competition increases. We also find a negative impact of import competition from China on all firms. Whereas for firms at the very top of the distribution the impact is lower and no longer significant the effect is especially negative for firms in lower deciles.

Panel 1 of Table 4 reports the results of OLS regressions for TFP estimates S2 [$p_i = p_{industry\text{-}year}$; for all continued product firm-year observations] and S3 [TFP^{S3}: $p_i = p_{firm,year}$; for continued-product firm-year observations]. We find that qualitatively results are maintained if compared to results for TFP estimate S1 [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations]. The magnitude of the impact is, however, significantly higher for TFP estimates S2 and S3. While we cannot exclude the possibility that sample selection affects the results, our evidence suggests that, if anything, traditional TFP estimates potentially underestimate the positive effects of import competition. In the case of import competition from China we find, in contrast, a stronger negative impact of import competition if we compare results to those for standard TFP estimates.

In Panel 2 of Table we show results for quantile regressions for TFP estimate S2 [$p_i = p_{industry\text{-}year}$; for all continued product firm-year observations]. We find the same progression showing that particularly more efficient producers manage to improve TFP more strongly than those at the bottom of the distribution. As for the negative impacts of China, while in general a negative impact is found we cannot observe a clear trend across deciles for this sample. Panel 3 of Table 4 shows the results using the TFP estimates S3 [TFP^{S3}: $p_i = p_{firm,year}$; for continued-product firm-year observations]. As before results suggest that firms at the very top of the TFP distribution benefit more and that the negative impacts of Chinese import competition are larger for firms at the bottom. What is striking for both the overall impact of competition and that from China is the significant difference between results from OLS and quantile regressions. If we compare the results of our quantile regressions across the different TFP measures quantitative differences are not as large as OLS regression results would suggest. This strengthens the finding that TFP measures of type S1 do not perform significantly different from measures that correct for mismeasurement due to product switching and firm-price deflated outputs.

4.2 Robustness

Table 5 shows the results of several robustness tests. First, we compare results as we impose a more stringent criterion on our TFP estimates removing the top and bottom 5% of observations. We find that the results are qualitatively maintained. Second, we address the potential endogeneity of trade costs discussed above by considering only trade costs corresponding to imports above 1000 USD in any one year.[65] The results are reported in Panel 2 of Table 5. Third, we examine whether our results would be maintained if we confined our analysis to the set of firms that are in the sample during the entire sample period. We find that this is indeed the case for all three TFP measures. Interestingly, the qualitatively stronger results for this subsample point towards larger benefits from import competition from the all countries except China and negative impacts from China.

Finally, we explore a different estimation technique that consists in having the log of output, $\log Y_{it}$ as the dependent variable and adding the production inputs, I_{it}, (i.e., the log of skilled and unskilled employment, materials, capital, services and energy) as controls resulting in the following estimating equation:

$$\log Y_{it} = \overline{\beta}_{TC1} * TCchina_{it-1}^{k4} + \overline{\beta}_{TC2} * TCall_{it-1}^{k4} + \tau * I_{it} + \gamma * X_{it} + I_t + I^{m3} * I_t + \varepsilon_{it}, \qquad (6)$$

We select the same three samples used above to obtain three distinct TFP estimates i.e. S1 [Y^{S1}: $p_i = p_{industry,year}$; for all firm-year observations], S2 [Y^{S2}: $p_i = p_{industry,year}$; for continued-product firm-year observations], and S3 [Y^{S3}: $p_i = p_{firm,year}$; for

[65] Chapter 3 discusses the reason for this robustness test in further detail.

continued-product firm-year observations]. The exercise is slightly different from the above as quantile regressions will divide firms according to their size (measured in terms of their revenue). The results are reported in Panels 1 to 3 of Table 6. Overall the OLS results are qualitatively similar to those for TFP though the signs are not significant for all three samples: a positive impact of competition from all countries with the exception of China and a negative impact of import competition from China. As for the quantile regressions, all consistently show a negative impact of import competition from China for small firms specifically and an apparently positive effect for larger firms. With the only exception of S3 estimates the evidence suggests that the positive effects are particularly powerful for firms at the top of the size distribution.

4.3 Why Does Chinese Import Competition Affect TFP Negatively?

It is somewhat surprising to find a significant negative impact of import competition from China on plant TFP. We would expect competition to stimulate efficiency improvements rather than the opposite which seems at first difficult to explain. The evidence provided in Chapter 4 does, however, provide a compelling explanation for this seemingly surprising result. That study shows that competition from developing countries including China stimulates firms' incremental product innovation to escape competition from abroad. Product upgrading requires the implementation of changes in firm production techniques and such adjustments may temporarily have a negative effect on TFP. The negative impact of substantial adjustments in technologies on TFP was found to be significant for Colombian plants by Hugget and Ospina (2001). There is also evidence demonstrating that specifically product innovation may lead to weaker or even negative TFP growth (Parisi et al., 2006; Harrison et al., 2005; and Hall et al., 2007). Note that in the case of our data we can exclude the possibility that negative effects are simply due to measurement problems as firms switch products and are instead effectively due to adjustments since results hold equally for TFP measures S2 and S3.

In order to test the validity of this explanation we first check whether there is indeed a differential impact of import competition from China compared to all other countries on product innovation. If there was no differential impact on product innovation, then this would not be the correct explanation for negative impacts of competition from China but not for all other countries. Since our hypothesis relies on adjustment costs introducing a temporarily negative effect on TFP, we select a more radical type of innovation than product improvement: new product adoption. Column (1) of Table 7 shows the results of a simple probit regression model explaining product adoption using the trade costs measures for China and all other countries as well as same controls as in the TFP regressions. We find indeed that only competition from China has a positive and significant impact on product adoption. The same does not hold for import competition from all other countries. This finding gives some support to our hypothesis.

However, it is possible that both effects are in fact unrelated. In order to explore whether our hypothesis finds support in the data we investigate in which industries classified according to their technological sophistication import competition from China results in negative effects. In order to do so we rely on the OECD (2005) classification of industries and obtain three industry categories: (1) high- and medium-technology industries, (2) medium-low-technology industries and (3) low-technology industries.[66] Results for all types of TFP estimates (S1, S2 and S3) are reported in columns (2), (3) and (4) of Table 7. The findings show that significant negative effects of import

[66] The classification is based on R&D expenditures and outputs of 12 OECD countries for the 1991-1999 period. Further detail is provided in OECD (2005).

competition from China are specifically concentrated in low-technology sectors. As shown in column (5) of the same table it is precisely in these industries that import competition from China stimulates product adoption.[67] Temporal adjustment costs for firms operating in these industries may well play an important role as firms change their product structure. Based on the evidence provided here, we therefore feel there is some evidence to conclude that the negative impact of Chinese import competition on TFP is likely a consequence of adjustment costs as Chilean firms engage in the production of new products at the temporary expense of efficiency. The fact that we find a stronger negative impact for smaller firms suggests that given lower production scales any re-adjustment is more costly for them than for bigger firms.

5. Conclusion

The increased availability of data on quantities and prices of firm manufactured products has both provided a means to solve some of the shortcomings of existing TFP measures and at the same time uncovered additional challenges for TFP estimates given the complexities of firm production patterns. In this chapter we focus on two important difficulties: *(i)* the fact that a large share of firms switch products over their lifetime; TFP estimates will likely suffer from important mismeasurement problems of production functions and *(ii)* the problem that industry-level price deflators for output will attribute higher TFP to plants with stronger market power. Using a popular TFP estimation technique in the empirical literature we find that the answer to the question of how import competition affects TFP is not affected by the correction for these two aspects in

[67] Note that product adoption probit regressions reported in columns (1) and (5) of Table 7 are based on the full sample of firms. Unreported regression results show that results are maintained if the sample is restricting to include sample S2 and sample S3 observations only.

TFP measurement. There is a consistently positive effect of stronger import competition from all countries with the exception of China on firm TFP in Chile.

This finding suggests that some of the prior literature would not have been different had the authors been able to correct for these two shortcomings. There are, however, other challenges that our improved TFP estimates do not address such as the use of correct input deflators. Moreover, there is a substantial debate about TFP estimation techniques themselves (Van Biesebroeck, 2007, Katayama et al., 2009). Further studies that examine how these measures compare to TFP measures obtained if firm product data are not available will be useful to evaluate findings of the existing literature that rely on these measures of TFP.

The negative impact of import competition from China points to a potential production restructuring process that causes temporary efficiency losses of firms. We show in Chapter 4 that competition from developing countries stimulates firm product upgrading and we have shown here that Chinese competition has a positive impact on product adoption. Losses in TFP are concentrated in low-technology sectors where most product adoption by Chilean firms takes place. Small firms have greater losses as adjustments are likely more radical and as they rely on fewer resources allowing them to invest in both efficiency improvements and product adjustment simultaneously.

There are, however, several shortcomings in our analysis have to be pointed out. Most importantly, while our measure of import competition, transport costs, might well capture import competition in Chile in firm product markets it is equally possible that it captures several other effects. One telling example is that the measure will equally capture the obstacles to imports of production inputs for firms. The evidence might actually measure impacts of differential access to production inputs. The story might rather be about lost learning opportunities than competition. Moreover, to the extent that transport costs to Chile are correlated with those for other countries such as, e.g., neighbour country, Argentina, our measure would also capture the effects of import competition in Argentina on Chilean firms. This could specifically affect those firms that export to the Argentinean market. These are important concerns that will require further analysis in order to strengthen findings reported here.

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Chapter 3: Tables

Table 1: Descriptive Statistics for the Final Estimation Samples

	S1 (17331 Observations)			S2 (12218 Observations)			S3 (11925 Observations)		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
LP(2003) TFP Estimates									
Log of plant TFP S1	2.633	2.585	0.592						
Log of plant TFP S2				2.613	2.552	0.573			
Log of plant TFP S3							2.612	2.550	0.567
Control Variables									
Industry share of FDI	0.123	0.106	0.123	0.124	0.106	0.122	0.125	0.106	0.123
Foreign ownership dummy	0.055	0	0.228	0.055	0	0.229	0.054	0	0.227
Change in firm market share	0	0	0.038	0	0	0.029	0	0	0.029
Normalised Herfindahl index	0.078	0.046	0.094	0.077	0.046	0.090	0.077	0.046	0.091
Exporter status dummy	0.217	0	0.412	0.199	0	0.399	0.196	0	0.397
Firm size dummy 1	0.224	0	0.417	0.210	0	0.407	0.206	0	0.406
Firm size dummy 2	0.070	0	0.254	0.062	0	0.241	0.062	0	0.241
Production Function Inputs									
Log of skilled employment	2.414	2.303	1.103	2.368	2.303	1.088	2.370	2.303	1.092
Log of unskilled employment	2.717	2.833	1.528	2.660	2.773	1.513	2.653	2.773	1.505
Log of materials inputs	12.349	12.025	1.740	12.260	11.921	1.709	12.256	11.910	1.715
Log of services inputs	10.208	10.400	2.706	10.066	10.257	2.705	10.101	10.272	2.668
Log of energy inputs	4.569	4.248	1.918	4.496	4.174	1.882	4.478	4.159	1.857
Log of capital	12.045	11.925	2.032	11.930	11.792	2.035	11.919	11.776	2.040
Plant Sales Volume									
Log of industry-price deflated output	13.046	12.717	1.687	12.954	12.596	1.668	12.951	12.592	1.666

Table 2: Transport Costs for Selected 4-digit Industries and Years

4-digit ISIC		1997	1999	2002
3112	Manufacture of dairy products	7.98%	6.46%	6.25%
3118	Sugar factories and refineries	10.67%	15.67%	14.02%
3212	Manufacture of made-up textile goods except wearing apparel	6.69%	7.74%	8.60%
3220	Manufacture of wearing apparel except footwear	4.98%	5.35%	5.13%
3312	Manufacture of wooden and cane containers and small cane ware	9.15%	6.29%	6.11%
3320	Manufacture of furniture and fixtures, except primarily of metal	13.72%	12.25%	13.98%
3122	Manufacture of prepared animal feeds	15.61%	12.91%	12.74%
3133	Malt liquors and malt	19.49%	12.61%	15.66%
3140	Tobacco manufactures	8.19%	8.46%	8.79%
3215	Cordage, rope and twine industries	4.33%	5.08%	6.39%
3233	Manufacture of leather and leather substitutes, except footware and wearing apparel	8.29%	9.85%	9.06%
3240	Manufacture of footwear, except vulcanised or moulded rubber and plastic footwear	5.20%	5.50%	5.81%
3412	Manufacture of containers and boxes of paper and paperboard	15.14%	10.52%	10.41%
3512	Manufacture of fertlizers and pesticides	11.21%	11.91%	10.95%
3551	Tyre and tube industries	7.95%	7.69%	8.25%
3560	Manufacture of plastic products not elsewhere specified	10.27%	10.04%	9.13%
3620	Manufacture of glass and glass products	13.49%	14.31%	13.84%
3720	Non-ferrous metal basic industries	4.64%	4.58%	4.06%
3822	Manufacture of agricultural machinery and equipment	6.51%	5.36%	6.21%
3831	Manufacture of electrical industrial machinery and apparatus	4.85%	4.63%	4.80%
3852	Manufacture of photographic and optical goods	3.36%	3.36%	3.85%
3420	Printing, publishing and allied industries	8.04%	8.74%	8.24%
3522	Manufacture of drugs and medicines	3.30%	3.07%	3.31%
3610	Manufacture of pottery, china and earthenware	11.85%	15.67%	13.97%
3710	Iron and steel basic industries	10.59%	10.06%	10.15%
3812	Manufacture of furniture and fixtures primarily of metal	12.20%	11.35%	12.94%
3813	Manufacture of structural metal products	9.80%	7.65%	8.05%
3844	Manufacture of motorcycles and bicycles	8.69%	10.56%	11.49%

Note: The table shows for each 4-digit industry transport costs aggregated from the level of the 8-digit HS code, exporting country, and year to the level of the 4-digit ISIC and year using as weights Chile's fob imports from each country and year.

Table 3: Impact of Transport Costs for All Countries except China and China on TFP Estimates (S1)

Panel 1: OLS Regression Results for TFP Estimates (S1)

	Dependent Variable: Log of Plant S1 TFP (LP, 2003)			
	OLS Regression Results			
	(1)	(2)	(3)	(4)
Transport Costs for All Countries Except China t-1	1.199***	1.138***	1.384***	1.333***
	(0.270)	(0.280)	(0.280)	(0.290)
Transport Costs for China t-1	-0.312***	-0.298***	-0.248**	-0.236**
	(0.110)	(0.100)	(0.110)	(0.110)
Plant Controls	No	No	Yes	Yes
Industry Controls	No	Yes	No	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	18967	18960	17337	17331
R-squared	0.51	0.51	0.53	0.53

Panel 2: Quantile Regression Results for TFP Estimates (S1)

	Dependent Variable: Log of Plant S1 TFP (LP, 2003)									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China t-1	1.333***	1.144***	1.258***	1.283***	1.296***	1.420***	1.333***	1.734***	1.914***	2.056***
	(0.290)	(0.310)	(0.230)	(0.200)	(0.200)	(0.180)	(0.190)	(0.220)	(0.230)	(0.370)
Transport Costs for China t-1	-0.236**	-0.462***	-0.345***	-0.319***	-0.329***	-0.313***	-0.232***	-0.372***	-0.163	-0.0519
	(0.110)	(0.150)	(0.110)	(0.089)	(0.092)	(0.083)	(0.083)	(0.094)	(0.099)	(0.150)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17331	17331	17331	17331	17331	17331	17331	17331	17331	17331

Notes: For ordinary-least squared regressions we report robust standard errors clustered at the firm-level in parentheses. For quantile regressions we report standard errors in parenthesis. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs. Plant controls include dummies for firm size, foreign ownership, exporter status as well as the change in firms' market shares between t-1 and t. Industry controls include the employment share of foreign firms over total employment by 4-digit industry as well as the normalised Herfindahl index.

Table 4: Impact of Transport Costs for All Countries except China and China on TFP Estimates (S2) and (S3)

Panel 1: OLS Regression Results TFP Estimates (S1), (S2) and (S3)

	OLS Regression Results Dependent variables: Log of Plant TFP (LP, 2003)		
	TFP S1	TFP S2	TFP S3
	(1)	(2)	(3)
Transport Costs for All Countries Except China $_{t-1}$	1.333***	3.972***	5.216***
	(0.290)	(0.820)	(1.440)
Transport Costs for China $_{t-1}$	-0.236**	-0.467*	-1.042***
	(0.110)	(0.250)	(0.320)
Plant Controls	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes
Observations	17331	12218	11925
R-squared	0.53	0.90	0.90

Panel 2: Quantile Regression Results for TFP Estimates (S2)

	Dependent Variable: Log of Plant S2 TFP (LP, 2003)									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China $_{t-1}$	3.972***	1.531***	1.230***	1.410***	1.329***	1.293***	1.387***	1.790***	2.188***	2.321***
	(0.820)	(0.480)	(0.320)	(0.260)	(0.210)	(0.240)	(0.330)	(0.300)	(0.360)	(0.480)
Transport Costs for China $_{t-1}$	-0.467*	-0.248	-0.309*	-0.343***	-0.373***	-0.369***	-0.389**	-0.501***	-0.420**	-0.208
	(0.250)	(0.240)	(0.160)	(0.130)	(0.100)	(0.110)	(0.160)	(0.140)	(0.170)	(0.210)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12218	12218	12218	12218	12218	12218	12218	12218	12218	12218

Panel 3: Quantile Regression Results for TFP Estimates (S3)

	Dependent Variable: Log of Plant S3 TFP (LP, 2003)									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China $_{t-1}$	5.216***	0.197	1.525***	1.153***	1.279***	1.468***	1.219***	1.426***	1.322***	2.180***
	(1.440)	(0.680)	(0.510)	(0.440)	(0.340)	(0.320)	(0.330)	(0.400)	(0.460)	(0.630)
Transport Costs for China $_{t-1}$	-1.042***	-1.096***	-0.967***	-0.803***	-0.790***	-0.772***	-0.611***	-0.521***	-0.424**	-0.535*
	(0.320)	(0.300)	(0.230)	(0.210)	(0.160)	(0.150)	(0.160)	(0.190)	(0.220)	(0.280)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11925	11925	11925	11925	11925	11925	11925	11925	11925	11925

Notes: For ordinary-least squared regressions we report robust standard errors clustered at the firm-level in parentheses. For quantile regressions we report standard errors in parenthesis. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs. Plant controls include dummies for firm size, foreign ownership, exporter status as well as the change in firms' market shares between t-1 and t. Industry controls include the employment share of foreign firms over total employment by 4-digit industry as well as the normalised Herfindahl index.

Table 5: Robustness Tables for TFP Estimates (S1), (S2) and (S3)

Panel 1: OLS and Quantile Regression Results Excluding the Top and Bottom 5% of TFP Estimates

	Dependent variables: Log of Plant TFP (LP, 2003)											
	TFP S1				TFP S2				TFP S3			
	OLS	Quantile Regressions			OLS	Quantile Regressions			OLS	Quantile Regressions		
		30	50	70		30	50	70		30	50	70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Transport Costs for All Countries Except China $_{t-1}$	1.380***	1.271***	1.343***	1.588***	3.304***	0.924***	1.203***	1.497***	2.994**	0.855*	0.619**	1.034***
	(0.240)	(0.180)	(0.170)	(0.220)	(0.750)	(0.260)	(0.260)	(0.270)	(1.230)	(0.440)	(0.260)	(0.340)
Transport Costs for China $_{t-1}$	-0.191**	-0.274***	-0.288***	-0.312***	-0.536**	-0.276**	-0.376***	-0.503***	-1.088***	-0.755***	-0.552***	-0.374**
	(0.092)	(0.080)	(0.073)	(0.092)	(0.220)	(0.130)	(0.120)	(0.120)	(0.280)	(0.200)	(0.120)	(0.160)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15908	15908	15908	15908	11192	11192	11192	11192	10936	10936	10936	10936

Panel 2: OLS and Quantile Regression Results Using Transport Cost Estimates Excluding Import Flows below 1,000 USD

	Dependent variables: Log of Plant TFP (LP, 2003)											
	TFP S1				TFP S2				TFP S3			
	OLS	Quantile Regressions			OLS	Quantile Regressions			OLS	Quantile Regressions		
		30	50	70		30	50	70		30	50	70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Transport Costs for All Countries Except China $_{t-1}$	1.333***	1.283***	1.420***	1.734***	3.972***	1.410***	1.293***	1.790***	5.216***	1.153***	1.468***	1.426***
	(0.290)	(0.200)	(0.180)	(0.220)	(0.820)	(0.260)	(0.240)	(0.300)	(1.440)	(0.440)	(0.320)	(0.400)
Transport Costs for China $_{t-1}$	-0.236**	-0.319***	-0.313***	-0.372***	-0.467*	-0.343***	-0.369***	-0.501***	-1.042***	-0.803***	-0.772***	-0.521***
	(0.110)	(0.089)	(0.083)	(0.094)	(0.250)	(0.130)	(0.110)	(0.140)	(0.320)	(0.210)	(0.150)	(0.190)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17331	17331	17331	17331	12218	12218	12218	12218	11925	11925	11925	11925

Panel 3: OLS and Quantile Regression Results for the Sample of Continued Firms

	Dependent variables: Log of Plant TFP (LP, 2003)											
	TFP S1				TFP S2				TFP S3			
	OLS	Quantile Regressions			OLS	Quantile Regressions			OLS	Quantile Regressions		
		30	50	70		30	50	70		30	50	70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Transport Costs for All Countries Except China $_{t-1}$	1.871***	1.529***	1.761***	2.153***	4.703***	1.793***	1.368***	2.063***	6.645***	1.716***	1.981***	1.997***
	(0.360)	(0.220)	(0.240)	(0.220)	(1.170)	-0.39	-0.31	-0.39	(1.980)	(0.450)	(0.470)	(0.520)
Transport Costs for China $_{t-1}$	-0.233*	-0.314***	-0.353***	-0.359***	-0.579*	-0.409**	-0.472***	-0.549***	-1.316***	-1.071***	-0.885***	-0.608**
	(0.130)	(0.093)	(0.100)	(0.091)	(0.340)	-0.18	-0.14	-0.17	(0.410)	(0.210)	(0.220)	(0.240)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11270	11270	11270	11270	8052	8052	8052	8052	7898	7898	7898	7898

Notes: For ordinary-least squared regressions we report robust standard errors clustered at the firm-level in parentheses. For quantile regressions we report standard errors in parenthesis. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs. Plant controls include dummies for firm size, foreign ownership, exporter status as well as the change in firms' market shares between t-1 and t. Industry controls include the employment share of foreign firms over total employment by 4-digit industry as well as the normalised Herfindahl index.

Table 6: Output regressions for output measures (S1), (S2) and (S3)

Panel 1: Output regressions for output measures (S1)

	Dependent variables: Log of real firm sales - Sample: S1									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China $_{t-1}$	0.421	0.065	0.208	0.279*	0.224	0.320**	0.299*	0.490***	0.693***	0.622**
	(0.260)	(0.220)	(0.170)	(0.150)	(0.180)	(0.140)	(0.150)	(0.190)	(0.200)	(0.290)
Transport Costs for China $_{t-1}$	-0.021	-0.345***	-0.234***	-0.189***	-0.094	-0.033	0.119*	0.097	0.108	0.217*
	(0.100)	(0.100)	(0.078)	(0.068)	(0.081)	(0.065)	(0.069)	(0.082)	(0.085)	(0.130)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inputs to Production	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17331	17331	17331	17331	17331	17331	17331	17331	17331	17331

Panel 2: Output regressions for output measures (S2)

	Dependent variables: Log of real firm sales - Sample: S2									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China $_{t-1}$	0.748**	0.332	0.381*	0.489***	0.378*	0.400**	0.585***	0.620***	0.815***	0.718*
	(0.350)	(0.290)	(0.210)	(0.180)	(0.200)	(0.200)	(0.220)	(0.180)	(0.260)	(0.380)
Transport Costs for China $_{t-1}$	-0.037	-0.392***	-0.254**	-0.235***	-0.115	0.000	0.098	0.177**	0.163	0.287
	(0.130)	(0.150)	(0.100)	(0.089)	(0.096)	(0.097)	(0.100)	(0.086)	(0.120)	(0.180)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inputs to Production	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12218	12218	12218	12218	12218	12218	12218	12218	12218	12218

Panel 3: Output regressions for output measures (S3)

	Dependent variables: Log of real firm sales - Sample: S3									
	OLS	Quantile Regressions								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs for All Countries Except China $_{t-1}$	0.563	1.375*	0.661	0.220	0.121	0.057	0.195	-0.007	0.237	0.393
	(0.510)	(0.780)	(0.420)	(0.380)	(0.310)	(0.250)	(0.330)	(0.350)	(0.420)	(0.510)
Transport Costs for China $_{t-1}$	-0.444**	-1.766***	-0.963***	-0.687***	-0.466***	-0.421***	-0.196	0.002	-0.078	0.093
	(0.200)	(0.330)	(0.190)	(0.180)	(0.140)	(0.120)	(0.150)	(0.170)	(0.200)	(0.230)
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inputs to Production	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11925	11925	11925	11925	11925	11925	11925	11925	11925	11925

Notes: For ordinary-least squared regressions we report robust standard errors clustered at the firm-level in parentheses. For quantile regressions we report standard errors in parenthesis. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs. Plant controls include dummies for firm size, foreign ownership, exporter status as well as the change in firms' market shares between t-1 and t. Industry controls include the employment share of foreign firms over total employment by 4-digit industry as well as the normalised Herfindahl index. Production inputs include the log of skilled workers, log of unskilled workers, energy consumption as well as a measure capital, materials and services used for production.

Table 7: Impact of Transport Costs on Product Adoption and TFP Distinguishing by Industrial Technological Intensity

	Product Adoption	TFP S1	TFP S2	TFP S3	Product Adoption
	Probit	OLS	OLS	OLS	Probit
	(1)	(2)	(3)	(4)	(5)
Transport Costs for All Countries Except China t-1	-3.146***				
	(0.950)				
Transport Costs for China t-1	2.018***				
	(0.450)				
Transport Costs for All Countries Except China * High- and Medium-Technology Industries t-1		-0.617	-1.436	2.551	-8.223***
		(0.810)	(2.220)	(1.950)	(2.080)
Transport Costs for All Countries Except China * Medium- Low-Technology Industries t-1		1.447*	6.053**	11.02**	-6.377***
		(0.780)	(2.460)	(5.080)	(2.420)
Transport Costs for All Countries Except China * Low-Technology Industries t-1		1.696***	4.581***	4.911***	-0.535
		(0.320)	(0.950)	(1.640)	(1.140)
Transport Costs for China * High- and Medium-Technology Industries t-1		0.359	-0.335	-1.365	1.686
		(0.680)	(1.580)	(1.430)	(1.720)
Transport Costs for China * Medium-Low-Technology Industries t-1		-0.0534	-0.774	-0.593	0.482
		(0.290)	(0.670)	(1.270)	(1.140)
Transport Costs for China * Low-Technology Industries t-1		-0.331***	-0.525**	-1.202***	2.167***
		(0.120)	(0.270)	(0.320)	(0.500)
Plant Controls	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	16825	17331	12218	11925	16825

Notes: Columns (1) and (5) report results of probit regressions of firm product adoption computed at the 7-digit product level. Columns (2), (3) and (4) are OLS regressions of TFP S1, S2 and S3 respectively. Columns (2) to (5) split transport costs estimates for all countries (except China) and China into three categories, high- and medium-technology industries, medium-low-technology industries and low-technology industries following the OECD classification (2005). For all regressions we report robust standard errors clustered at the firm-level in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs. Plant controls include dummies for firm size, foreign ownership, exporter status as well as the change firms' market shares between t-1 and t. Industry controls include the employment share of foreign firms over total employment by 4-digit industry as well as the normalised Herfindahl index.

Appendix

1. Data Issues

Computing firm-level output prices

We obtain firm-level output prices by deflating nominal sales by a firm-level price index which is obtained computing Tornquist indices as proposed by Eslava et al. (2004). First, we obtain a weighted average of the growth of the prices of plant *j*'s products *i* between time *t* and *t-1* where P_{ijt} are prices charged for product *i* of plant *j* at time *t* while s_{ijt} and s_{ijt-1} are shares of product *i* in plant *j*'s total production for years *t* and *t-1*.

$$\Delta P_{jt} = \sum_{i=1}^{I} \bar{s}_{ijt} \Delta \ln(P_{ijt}), \qquad \text{(A1)}$$

where

$$\Delta \ln(P_{ijt}) = \ln P_{ijt} - \ln P_{ijt-1}$$

and

$$\bar{s}_{ijt} = \frac{s_{ijt} - s_{ijt-1}}{2}$$

The distribution of the weighted average of the growth in prices has large outliers. We, therefore, treat all firm average price growth rates below -50% and above 100% as missing. The indices for the levels of output prices for each plant *j* are constructed as follows:

$$\ln P_{jt} = \ln P_{ijt-1} + \Delta P_{ijt} \qquad \text{(A2)}$$

Using this information, we fix 1996 as the base year and compute prices relative to the base year, setting Pj_{1996} = 100. The construction of price indices requires a common base year for all firm observations. As this is an unbalanced sample we do not have information for all firms for the year 1996. In order to be able to use information for those firms as for others as well as to deal with missing observations, we follow Eslava et al. (2004) and impute product prices for plants with missing values using average prices in their sector, location and year.

Production Function Variables

We compute two distinct output measures for our analysis and use the same five inputs used in Chapter 2: skilled and unskilled labor, materials, electricity, services and capital. These inputs are the same for all three production function estimations and TFP estimates. The following provides detail as to how these variables were computed.

Skilled and unskilled labor are measured by the number of workers in the following occupational categories: (a) skilled: owners, managers, administrative personnel, and specialized production workers, and (b) unskilled: workers directly or indirectly involved in the production process, and home workers.

Materials is measured by deflated materials expenditures. The materials price deflator is based on a weighted average of the aforementioned 3-digit output price deflators where the weights are given by the share that each 3-digit industry's output represents in total manufacturing intermediates used by all 3-digit industries based on an input-output table. For years 1992-2002 [2003-2004], the weights are based on the 1986 [1996] Chilean input-output table.

Electricity is the quantity of electricity bought plus the quantity of electricity generated minus the quantity of electricity sold in thousands of kilowatts.

Services is measured by the deflated sum of expenditures on advertising, banking commissions and interest payments, communications, insurance, legal, technical, and accounting services, licenses and foreign technical assistance, rental payments, transport, other services, and water. The services price deflator is based on GDP deflators for 4 groups of services from the Chilean Central Bank: (i) electricity and water, (ii) transport and communications, (iii) financial services, insurance and business services, and (iv) real estate. We calculate a weighted average of these GDP deflators where the weights are given by the share that each of these 4 groups of services represents in total intermediate expenditures (manufacturing plus services) for each 3-digit industry based on the 1996 Chilean input-output table.

Capital is computed using the perpetual inventory method (PIM). The ENIA survey provides information on four types of capital: buildings, machinery and equipment, transport equipment, and land. For each type of capital we compute net investment flows as the sum of purchases of new capital, purchases of used capital and improvements to capital minus the sales of capital and deflate these by an investment price deflator constructed as the ratio of current gross capital formation to constant gross capital formation (in local currency units) from the World Development Indicators with base year 2002. For each type of capital, the PIM formula $K_{it+1} = (1 - \delta) K_{it} + I_{it}$ is applied, where I_{it} are real net investment flows and δ is a depreciation rate. Since detailed studies of depreciation rates in Chile are unavailable, we use the following rates proposed by Pombo (1999) who studied the same type of capital goods in Colombia: 3% for buildings, 7% for machinery and equipment, and 11.9% for transport equipment. Land is assumed not to depreciate. We also experimented with alternative rates of depreciation but did not find this to make a substantial difference to the final capital stock values nor to our main results. The initial value of the capital stock needed to apply the PIM formula is given by the book value of each of the four types of capital in the first year of plant presence in the sample. Whenever the book value is available only in a latter year, we back out that value until the plant's first year in the sample taking into account the investment price deflator and the corresponding depreciation rate.

Output is measured by deflated sales. For traditional TFP estimation (S1) [TFP^{S1}: $p_i = p_{industry,year}$; for all firm-year observations] and the continued products sample (S2) [TFP^{S2}: $p_i = p_{industry,year}$; for continued-product firm-year observations] the output price deflator is based on information on indexes of total sales and indexes of physical production for each 3-digit industry from the Chilean Statistical Institute. Based on the equality total sales=physical production * price, one obtains growth in total sales=growth in output + growth in prices. Using this formula we compute an industry output price deflator using 2002 as the base year. For years 1992-2002, the price deflator is obtained for 3-digit ISIC Rev. 2 industries while for 2003-2004 it is obtained for 3-digit ISIC Rev. 3 industries. For the improve TFP estimate (S3) [TFP^{S2}: $p_i = p_{firm,year}$; for continued-product firm-year observations] we deflate sales by the firm-level price index specified above. The latter were used for the other two samples (S1 and S2). To avoid possible outlier problems, we drop the top and bottom 1% of TFP levels estimates for all three samples (S1, S2 and S3) of observations from our main regression sample.

2. Production Function Coefficient Estimates

Chapter 3 - Appendix: Tables

Table 1: Estimation using industry-level output price deflators for all plants, 1996 - 2003

	Dependent Variable: Log of Output								
	Levinsohn and Petrin (2003) Estimation								
	Food (ISIC 31)	*Textiles Apparel (ISIC 32)*	*Wood Furniture (ISIC 33)*	*Paper Printing (ISIC 34)*	*Chemicals (ISIC 35)*	*Nonmet. Minerals (ISIC 36)*	*Basic Metals (ISIC 37)*	*Machinery (ISIC 38)*	*Other Manuf. (ISIC 39)*
Log of Skilled Labor	0.081***	0.161***	0.088***	0.169***	0.169***	0.107***	0.153***	0.137***	0.231***
	(0.009)	(0.015)	(0.021)	(0.020)	(0.028)	(0.028)	(0.046)	(0.019)	(0.054)
Log of Unskilled Labor	0.054***	0.083***	0.051***	0.033***	0.028**	0.036**	0.004	0.075***	0.143***
	(0.006)	(0.011)	(0.011)	(0.011)	(0.014)	(0.014)	(0.020)	(0.011)	(0.025)
Log of Materials	0.760***	0.670***	0.731***	0.663***	0.682***	0.643***	0.562***	0.648***	0.621***
	(0.011)	(0.016)	(0.021)	(0.019)	(0.030)	(0.003)	(0.038)	(0.014)	(0.061)
Log of Services	0.006**	0.071***	0.035***	0.017**	0.014**	-0.01***	-0.017	0.050***	-0.008
	(0.003)	(0.012)	(0.007)	(0.008)	(0.005)	(0.003)	(0.011)	(0.010)	(0.023)
Log of Electricity	0.140***	0.120***	0.150**	0.010	0.170**	0.260**	0.010	0.150***	0.030
	(0.034)	(0.042)	(0.059)	(0.028)	(0.070)	(0.113)	(0.111)	(0.022)	(0.048)
Log of Capital	0.020	0.010	0.010	0.270	0.040	0.010	0.390	0.010***	0.060
	(0.015)	(0.061)	(0.257)	(0.169)	(0.255)	(0.014)	(0.330)	(0.001)	(0.119)
Number of Observations	10394	5018	3285	2132	3961	1432	529	5923	424

Notes: Bootstrapped standard errors clustered at the plant-level in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level, respectively.

Table2: Estimation using industry-level output price deflators for plants that do not change their production, 1996 - 2003

	Dependent Variable: Log of Output								
	Levinsohn and Petrin (2003) Estimation								
	Food (ISIC 31)	*Textiles Apparel (ISIC 32)*	*Wood Furniture (ISIC 33)*	*Paper Printing (ISIC 34)*	*Chemicals (ISIC 35)*	*Nonmet. Minerals (ISIC 36)*	*Basic Metals (ISIC 37)*	*Machinery (ISIC 38)*	*Other Manuf. (ISIC 39)*
Log of Skilled Labor	0.087***	0.156***	0.092***	0.202***	0.172***	0.093***	0.167**	0.112***	0.251***
	(0.009)	(0.018)	(0.025)	(0.024)	(0.039)	(0.030)	(0.084)	(0.023)	(0.079)
Log of Unskilled Labor	0.058***	0.092***	0.064***	0.041***	0.024*	0.047***	0.020	0.063***	0.145***
	(0.006)	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)	(0.035)	(0.012)	(0.038)
Log of Materials	0.745***	0.668***	0.727***	0.647***	0.690***	0.660***	0.516***	0.653***	0.653***
	(0.014)	(0.022)	(0.027)	(0.021)	(0.048)	(0.024)	(0.064)	(0.016)	(0.060)
Log of Services	0.006**	0.081***	0.026***	0.020*	0.009	-0.011***	-0.045**	0.051***	-0.017
	(0.003)	(0.017)	(0.008)	(0.011)	(0.006)	(0.003)	(0.018)	(0.012)	(0.023)
Log of Electricity	0.180**	0.100*	0.040	0.080	0.030	0.200**	0.100	0.050	0.010
	(0.089)	(0.051)	(0.048)	(0.051)	(0.104)	(0.100)	(0.133)	(0.063)	(0.057)
Log of Capital	0.010	0.010	0.460	0.090	0.750**	0.030***	0.340	0.060	0.010
	(0.911)	(0.163)	(0.311)	(0.338)	(0.330)	(0.011)	(0.246)	(0.116)	(0.208)
Number of Observations	7050	2819	1690	1292	2216	930	270	3235	252

Notes: Bootstrapped standard errors clustered at the plant-level in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level, respectively.

Table 3: Estimation using firm-level output price deflators for plants that do not change their production, 1996 - 2003

	Dependent Variable: Log of Output								
	Levinsohn and Petrin (2003) Estimation								
	Food (ISIC 31)	*Textiles Apparel (ISIC 32)*	*Wood Furniture (ISIC 33)*	*Paper Printing (ISIC 34)*	*Chemicals (ISIC 35)*	*Nonmet. Minerals (ISIC 36)*	*Basic Metals (ISIC 37)*	*Machinery (ISIC 38)*	*Other Manuf. (ISIC 39)*
Log of Skilled Labor	0.094***	0.173***	0.045	0.240***	0.218***	0.114***	0.183**	0.147***	0.261***
	(0.013)	(0.025)	(0.032)	(0.027)	(0.042)	(0.032)	(0.089)	(0.032)	(0.093)
Log of Unskilled Labor	0.058***	0.106***	0.072***	0.059***	0.046***	0.041*	0.006	0.090***	0.196***
	(0.010)	(0.019)	(0.020)	(0.015)	(0.017)	(0.021)	(0.032)	(0.017)	(0.042)
Log of Materials	0.743***	0.651***	0.744***	0.557***	0.637***	0.622***	0.592***	0.610***	0.626***
	(0.017)	(0.027)	(0.026)	(0.027)	(0.055)	(0.030)	(0.067)	(0.019)	(0.084)
Log of Services	0.006	0.076***	0.030***	0.040***	0.021**	-0.010**	-0.055**	0.050***	-0.022
	(0.004)	(0.015)	(0.009)	(0.013)	(0.010)	(0.005)	(0.022)	(0.013)	(0.027)
Log of Electricity	0.160**	0.100*	0.010	0.010	0.280**	0.010	0.200	0.040	0.010
	(0.064)	(0.055)	(0.112)	(0.065)	(0.110)	(0.116)	(0.138)	(0.054)	(0.085)
Log of Capital	0.010	0.010	0.980**	0.480**	0.020	0.010	0.140	0.020	0.570**
	(0.280)	(0.098)	(0.429)	(0.204)	(0.215)	(0.107)	(0.198)	(0.049)	(0.283)
Number of Observations	7033	2744	1596	1167	2143	845	243	3135	240

Notes: Bootstrapped standard errors clustered at the plant-level in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level, respectively.

Chapter 4: Does Tougher Import Competition Foster Product Quality Upgrading?*

(Co-authored with Ana M. Fernandes, The World Bank)

Abstract

This chapter examines whether the increased exposure to import competition affects product quality upgrading using a rich dataset of Chilean manufacturing plants and their products. We measure product quality with product unit values and use industry-level transport costs as an exogenous measure of import competition. In line with the "escape competition" hypothesis of innovation, our estimates show a positive and robust effect of import competition on product quality. Our evidence suggests that while import competition contributes to quality upgrading and this holds especially for non-exporting plants, competitive pressure alone will not enable plants to catch up with leading world producers.

Keywords: import competition, transport costs, product quality, incremental innovation, output unit values, plant-level data, Chile.

JEL Classification codes: O31, F14, L6.

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1. Introduction

The acceleration in globalization witnessed over the last two decades and the corresponding increased exposure to competition from low-price producers in China and India have created a new economic environment for emerging economies (World Bank, 2006; OECD-WEF, 2008). Since production costs - especially those that are wage-related - cannot be infinitely reduced, the main way for manufacturing firms in those economies to position themselves in domestic and international markets is to focus on offering upgraded and differentiated rather than “mundane” labor-intensive products (Moreira, 2007). Pietrobelli and Rabellotti (2006) argue that such upgrading will provide the “high road” to competitiveness offering higher revenues and wages in contrast to the “low road” which would require price reductions squeezing revenues. Many factors can facilitate taking on the “high road”, one of them is the competitive pressure from abroad which may force firms to improve their products to stay in business. In this chapter, we provide a rigorous empirical foundation to this hypothesis by examining the following question: does increased exposure to import competition foster firm product quality upgrading?

Innovation plays a crucial for growth and welfare (Grossman and Helpman, 1991; Aghion and Howitt, 1998). However, the effects of competition on innovation are the object of some theoretical controversy and the empirical evidence is not always clear-cut as discussed below. Our study fills a gap in the literature by examining a potentially important determinant of incremental innovation reflected in product quality upgrading: import competition.[68] In an emerging economy context it is all the more relevant to

[68] We follow Pietrobelli and Rabellotti (2006) in equating product quality upgrading with innovation “to increase value-added”.

focus on such upgrading since most firms lag behind the world's technology frontier so radical innovation outcomes are less forthcoming.

While the idea of linking import competition to product quality upgrading is appealing, its empirical implementation faces two challenges. The first challenge concerns the measurement of product quality. To address it, we exploit a new dataset including rich information from census data on all the products manufactured by all Chilean plants during the 1997-2003 period. We follow the empirical trade literature and use unit values (prices) of products to measure their unobserved quality or sophistication.[69] The second challenge concerns the difficulty in identifying causal effects of import competition on quality upgrading as upgrading can itself affect whether and how much foreign competitors choose to export to the domestic market. To address it, we rely on an effective trade barrier measure - transport costs - which capture differences in import competition across industries that are exogenous to quality upgrading.

Our econometric approach exploits the variation in transport costs across 4-digit industries and over time and consists of regressions of product unit values on a lagged measure of transport costs, a set of plant and industry control variables, as well as product, plant, year, and industry-year fixed effects. Importantly, our specifications identify impacts by establishing comparisons of unit values across plants *within* product categories. No attempt is made to distinguish higher-quality from lower-quality products since differences across products in units of measurement and other characteristics preclude the direct comparability of their unit values.

[69] Iacovone and Javorcik (2008), Kugler and Verhoogen (2008), and Lelarge and Nefussi (2008) use data on unit values of domestic or exported products to proxy for product or export quality at the plant level, while Kiyota (2008) and Schott (2008) use data on unit values of exports to proxy for export quality at the country level.

Our main finding suggests that import competition has a positive and significant impact on plant-level product quality upgrading. The magnitude of the estimated impact increases as our sample is progressively restricted to include all plants but only the products that they neither start producing nor discontinue producing during the sample period (continued products) and then to include only the plants in the sample during the entire period of analysis (continuing plants) and their continued products. This difference in magnitudes suggests that products with less upgrading potential are likely to be discontinued by plants and new products are also less subject to upgrading as a result of import competition after their initial introduction.

It seems to be mainly increased import competition from less advanced economies that leads to the average positive impact of import competition on quality upgrading. This finding suggests that while increasing the sophistication of products is a distinct option that Chilean plants use to escape competition from less advanced economies, competition from more advanced economies does not engender the same response. Focusing on the differential impacts of tougher import competition across plants, we find that domestic-owned plants that do not export their products exhibit the strongest response in terms of quality upgrading. This is likely the case because the other plants are already exposed to international competition through other channels. We also show that increased import competition provides a significantly larger boost to the quality of products sold only in the domestic market than to the quality of products that are also (or exclusively) exported. Finally, we provide evidence that import competition is associated with a wider divergence in quality within product categories, which may suggest the presence of heterogeneous impacts of competition on plants with different productivity.

We successfully submit our results to a variety of tests. Our results are robust to the use of multiple outlier criteria and to the inclusion of additional or alternative control variables. Our findings are also maintained if different lags of the transport cost measure or alternative transport cost measures are used, suggesting that endogeneity problems are not a concern. A different concern about our results arising from the use of plant product prices as our outcome of interest is that the imports-as-market-discipline-hypothesis predicts a negative effect of import competition on prices and price-cost margins (Levinsohn, 1993; Melitz and Ottaviano, 2008). Since radical trade liberalization in Chile occurred in the early 1980s, we would not expect the pro-competitive price-lowering effects (the aforementioned “low road”) as a reaction to imports to still play a major role during our sample period. Indeed, we are able to dismiss those concerns based on our estimation of the link between transport costs and price-cost margins of Chilean plants following the widely used methodology proposed by Roeger (1995). Finally, while the use of unit values to signal product quality is well-founded in the industrial organization and the trade literatures, we provide explicit evidence confirming that our estimated increases in unit values due to tougher import competition are indeed picking up improvements in product quality. While we believe that those analyses and checks contribute to strengthening our findings, there are a couple of limitations to our findings as will be discussed in the concluding section.

This chapter relates to the debates in two strands of the literature. First, theoretical and empirical studies on product market competition and innovation are unclear about the sign of that relationship (Ahn, 2002). In a seminal contribution, Schumpeter (1942) argues that producers facing less competition are best placed to innovate since getting adequate returns for one’s innovation requires some form of temporary monopoly power. In contrast, strong competition may foster innovation as producers need to escape their innovating peers to stay in business. Aghion et al. (2005, 2006) predict and show evidence of an inverse U-shaped relationship between competition and innovation on a model which allows for counteracting 'escape competition' effects as well as 'Schumpeterian' effects of competition on innovation. Gorodnichenko et al. (2008), however, find no support for the inverse U-shaped relationship. Second, the theoretical literature on within-plant margins of adjustment to increased import competition is ambiguous about the incentives for plants to invest in productivity-enhancing technology and innovate.[70] In Goh (2000) import competition increases these incentives by reducing the opportunity cost of technological effort and in Thoenig and Verdier (2003) it results in defensive skill-intensive innovations by plants desiring to reduce future threats of imitation or leapfrogging by competitors. In contrast, Rodrik (1992) argues that by reducing the plant's market share, import competition may actually decrease its incentives to innovate, reviving the arguments of Schumpeter (1942).

To the best of our knowledge, empirical studies examining the effects of import competition on plant-level innovation outcomes are rare and those available differ in important aspects from ours. Bertschek (1995) and Baldwin and Gu (2004) examine the effect of import competition measuring German and Canadian plants' involvement in product upgrading or innovation by an affirmative answer to the question: 'Did you introduce new or significantly improved goods'.[71] Lelarge and Nefussi (2008) study the link between import competition from low-wage countries and French plants' research

[70] See Tybout (2000) for a survey of the literature.
[71] Alvarez and Robertson (2004) use a similar question to relate innovation outcomes for Chilean and Mexican plants to alternative dimensions of openness: foreign direct investment and exports.

and development (R&D) spending and the effect of the latter on exported products' unit values, in the absence of information on domestically sold products.

Our study's contributions to the literature are four-fold. First, ours is the first study to examine the impact of import competition on incremental rather than radical R&D-intensive innovation at the plant level for an emerging economy. Indeed, this is the type of innovation that is more prevalent in emerging economies where producers often improve upon products imported from developed countries. Second, we measure incremental innovation using direct quantitative information on product prices instead of relying on subjective perception-based measures of product upgrading as in previous studies. Third, we analyze the effects of import competition on quality upgrading for the universe of Chilean manufacturing products whereas most previous studies focus on exported products. This feature of the analysis is particularly important given that 86 percent of the products manufactured by Chilean plants are sold only in domestic markets. Furthermore, exported products may differ in many respects from domestically sold products, thus estimates obtained focusing exclusively on the former may be biased. Fourth, our identification of the effects of import competition on product quality relies on the use of a measure of transport costs that separates freight costs from insurance costs and thus improves upon that used by Bernard et al. (2006a) for U.S. industries and can confidently be considered exogenous to quality upgrading.

Our findings suggest that increased exposure to import competition, including that from China and India, may be beneficial by encouraging producers to follow the "high road" to competitiveness (Pietrobelli and Rabellotti, 2006). Taking into account the evidence provided by Iacovone and Javorcik (2008) that Mexican plants invest in product quality upgrading before they export, our findings suggest that over time plants -

including those with no export experience - may be able to progressively target more sophisticated export markets. However, our evidence also suggests that import competition may be insufficient to enable quality upgrading where the technology gap between foreign competitors and local producers is high. Other policy tools will be necessary to encourage more radical innovation in products.

The remainder of the chapter proceeds as follows. Section 2 describes the data and Section 3 presents the empirical specification. Section 4 discusses our main results, robustness tests, evidence of quality upgrading, and the imports-as-market-discipline hypothesis. Section 5 examines the differential impacts of import competition by type of exporting country and by type of plant and product. Section 6 concludes.

2. Data

2.1 Plant Unit Values and Other Information

In our analysis, we use a dataset with information on products at the plant level from 1997 to 2003 that is merged with the annual manufacturing census of Chilean plants with more than 10 employees (ENIA). Both datasets are provided and collected by the Chilean National Statistical Office. The products dataset includes information for each plant and year on the physical quantity sold and the sales value of each of 2,018 products at the 7-digit ISIC level (revision 2). Appendix Table 1 provides some examples of 7-digit ISIC categories to illustrate the level of detail of the products. The ENIA census described in detail in Chapter 2 is an unbalanced panel of plants capturing entry and exit that includes information on basic plant characteristics such as employment, ownership and on accounting variables such as sales.

For each product *p7* of plant *i* in year *t* we construct a unit value as $UV_{it}^{p7} = S_{it}^{p7} / Q_{it}^{p7}$, where S is the value of sales and Q is the physical quantity sold. A unit value measures the average price charged by a plant for each product in a year. We assume that an increase in unit values proxies for plant product quality upgrading. Our dataset reports the physical quantities of the 2,018 products in 20 different measurement units, some of which are shown in Appendix Table 1. The unit values for products measured in different units (e.g., price per kilogram, price per liter) are not comparable. To obtain our final estimating sample, we address two issues on the measurement units of the products' physical quantities: (i) some plants do not report the measurement unit of their products' quantity, and (ii) some plants report their products' quantity in a different unit than the unit in which the majority of plants report product quantities. The unit values of both types of plants cannot be compared to those of other plants producing the same 7-digit product and are thus excluded from the final sample. Further, to eliminate potential outliers we exclude the top and bottom 5% of the distribution of unit values for any 7-digit product. Appendix 2 describes further the cleaning procedures used for the products dataset and some tests performed to assess the goodness of the data. Our final sample combining the products dataset with the ENIA census includes 55,294 plant-year-product observations with the average number of products manufactured per plant being 2.3. Navarro (2008) shows that many stylized facts based on the Chilean products dataset are similar to those obtained for a U.S. products dataset by Bernard et al. (2006b) and an Indian products dataset by Goldberg et al. (2008).[72]

[72] For example, the average shares of the most important product, the second most important product, and so on, in total sales of Chilean multi-product plants are strikingly similar to those of U.S. and Indian multi-product plants.

Table 1 shows average coefficients of variation in unit values for selected 4-digit industries. The statistics show a substantial degree of heterogeneity in unit values across plants and point to some interesting differences across industries. Industries with homogeneous products and thus less scope for quality differences such as cement or petroleum refineries are characterized by low average coefficients of variation. However, industries where quality is expected to play a more important role such as electrical machinery, motorcycles, and professional equipment are characterized by higher coefficients of variation.

2.2 Transport Costs

Our measure of transport costs is based on detailed information provided by the Latin American Integration Association (ALADI) on freight costs excluding insurance costs and the free on board customs value (fob) of Chilean imports for each 8-digit Harmonized System (HS) code, exporting country, and year from 1997 to 2003. First, we compute for 8-digit HS code *i* from exporting country *c* in year *t* freight rates as the ratio of freight costs ($freight_{ict}$) to the fob value of imports (fob_{ict}): $TC_{ict} = freight_{ict} / fob_{ict}$. Second, we aggregate these freight rates from the 8-digit HS code, exporting country, and year level to the 4-digit ISIC (revision 2) and year level using (i) a concordance between 8-digit HS and 4-digit ISIC codes and (ii) weights given by Chile's 8-digit HS fob imports from each exporting country and year as a ratio to Chile's total imports in the corresponding 4-digit ISIC code in that year. Appendix 2 provides more details on the construction of the freight costs measure hereafter referred to as 'transport costs measure'.

Table illustrates the substantial variation in our transport costs measure over time and across a selection of 4-digit industries. Since some countries may not export a product to Chile due to prohibitive transport costs, our measure is a lower bound for transport costs accounting only for those of exports that actually occur (Hummels, 2001). However, as this feature of our measure is common to all products, it does not impair our analysis which focuses on differences in the relative rather than the absolute magnitude of transport costs across industries and time.

Transport costs proxy adequately for the exposure to import competition of plants in Chilean industries during the sample period for four reasons. First, export choices are to some extent driven by freight costs. For example, within disaggregate product categories, exporters with the lowest freight rates are shown to have the largest import shares based on data for the U.S., New Zealand, Argentina, Brazil, Chile, Paraguay, and Uruguay (Hummels, 2001). Second, transport costs can play an important role in "altering patterns of trade across goods and partners" due to their size and variability across trade partners (Hummels et al., 2008). Third, transport costs represent currently a greater share of trade costs than tariffs for most countries including Chile (Anderson and Wincoop, 2004).[73] Fourth, our transport costs measure excludes insurance costs and, therefore, does not suffer from the related concerns of endogeneity.

Finally, note that our transport costs measure is obtained at the 4-digit ISIC revision 2 level. A more aggregate measure may not adequately capture the degree of import competition faced by plants. For example, 3-digit industry 311, food

[73] The most usual measure of trade barriers - tariffs - is not informative in the Chilean context due to the uniform tariff structure across industries in place since the 1980s' trade liberalization (Chumacero et al., 2004). Chile's entry into preferential trade agreements with various countries and regions since the 1990s introduced a complex set of product- and country-specific exceptions to that uniform tariff structure that could provide useful variation for our analysis. However, such exceptions are subject to political economy pressures and likely to be endogenous to product quality in an industry.

manufacturing, includes 4-digit industries ranging from fruit and vegetable canning to bakery. If we considered a transport costs measure at the 3-digit level, an increase in imported bakery products would erroneously suggest that fruit and vegetable canning products also faced stronger import competition, when such products are not exactly substitutes. Certainly, one could argue that measuring import competition at the 4-digit level for bakery products (ISIC 3117) is still too aggregate. An import competition measure at the 4-digit level implies that increased imports of cookie products strengthen the competition faced by cake products too. Cake products may indeed be challenged by imports of cookie products because consumers may decide to substitute cake for cookie products. If competition was measured at a more disaggregate level - i.e., distinguishing cake from cookie products - then one might wrongly ignore that cross-effect. Hence, we consider 4-digit to be an adequate level at which to measure the degree of import competition as it accounts for a reasonable degree of substitutability across products.

3. Empirical Framework

To examine the impact of import competition on product quality, we need to account for the fact that 49 percent of Chilean plants manufacture multiple 7-digit products. Among these multi-product plants in any given year, 55 percent manufacture products within a single 4-digit industry whereas the remainder manufacture products across at least two different 4-digit industries.[74] As mentioned in Section 2.2, transport costs are measured at the 4-digit level. Thus, plants manufacturing 7-digit products in various 4-digit industries face a different degree of import competition in each of the 4-digit industries to which their products belong. The specification which allows us to

[74] Thus, in any given year about 78% of Chilean plants manufacture products within a single 4-digit industry.

examine quality upgrading responses to changes in the transport costs faced by each of the plant's products is given by:

$$\log UV_{it}^{p7} = \overline{\beta}_{TC} * TC_{it-1}^{k4} + \gamma * X_{it} + I^{p7} + I^{m3} * I_t + f_i + \varepsilon_{it}^{p7}, \qquad (1)$$

where $\log UV_{it}^{p7}$ is the log of the unit value for 7-digit product *p7* manufactured by plant *i* in year *t*, TC_{it-1}^{k4} are transport costs for 4-digit industry *k4* to which the plant's product *p7* belongs, X_{it} is a vector of controls to be specified below, I^{p7} are 7-digit product fixed effects, $I^{m3} * I_t$ are 3-digit industry *m3*-year fixed effects, f_i are plant fixed effects, and ε_{it}^{p7} is an independent and identically distributed (i.i.d.) residual.

We now discuss various econometric issues associated with the estimation of Equation (1). First, there is a possibility of reverse causality as product quality may affect import competition. Improvements in product quality in Chile may encourage the opening of its economy to further trade (e.g., by reducing lobbying pressures against openness) and result in tougher import competition. This issue does not concern us, though, since our measures capture 'external' transport costs incurred by imports from the exporting country until the arrival to Chilean ports and thus are not affected by Chilean trade policy decisions. Moreover, even if Chilean policy-makers attempted to reduce trade-related insurance costs or to improve the quality of domestic ports, those actions would not be captured by our measure of transport costs which excludes insurance costs. This advantage of our measure relative to that of Bernard et al. (2006a) is particularly relevant as insurance costs increase with the value - and likely the quality - of an exported product (Hummels et al., 2008).

Nevertheless, there are two possible ways in which product quality could affect transport costs. The first possibility is that if certain countries' producers stopped exporting to Chile due to improved domestic product quality, our measure of transport costs could be affected since those countries no longer enter the transport costs' calculation. If these countries used to export high-quality products to Chile, then the import competition faced by Chilean plants in these 4-digit industries would be effectively reduced. However, the new measure of transport costs would only increase, reflecting this decline in competition, if those countries also had low transport costs. It is likely that it would be producers in countries exporting smaller quantities to Chile that would stop exporting and that exporting smaller quantities would be linked to higher transport costs. Thus, measured transport costs could decrease as a result of quality upgrading. This issue is relevant for our analysis to the extent that only half of Chile's import relationships at the country-4-digit industry level last the entire sample period.[75] However, since our measure is a weighted average of transport costs across all countries, the exclusion of a country is unlikely to affect it unless it is one of Chile's largest trading partners. Our data shows that few large trading partners stop exporting any 4-digit categories to Chile during the sample period.[76] Nonetheless, we consider this issue in our robustness checks in Section 4.2 and find that our results are not driven by this potential reverse causality channel. The second possibility is that improvements in product quality in Chile could motivate producers in certain countries to export smaller quantities to Chile. This would result in higher freight rates if exporters no longer benefit from economies of scale in the transportation of their products. In this case, quality upgrading would result in weaker import competition and actually work against the finding of a

[75] Out of 4,960 country-4-digit industry pairs in Chilean imports, 2,449 (49%) last the entire sample period. Excluding import flows below 5,000 USD, out of 3,866 country-industry pairs, 2,428 (63%) last the entire sample period.

[76] Considering the top 10 exporting countries to Chile for each 4-digit industry, 4,400 out of 4,764 observations (94%) correspond to relationships that last the entire sample period.

positive effect of import competition on quality upgrading. However, the importance of such scale economies in affecting freight rates is unclear. These two possibilities by which quality upgrading could affect transport costs may lead to biases in the estimate of β_{TC}. To help mitigate these potential biases, we follow Bernard et al. (2006a) and include a one-year lag of the variable *TC* as shown in Equation (1).[77]

Second, unit values reflect a combination of quality and cost attributes such as input prices. Specifically, higher costs of production at the plant level may, depending on the market's level of competition, lead to increases in unit values unrelated to quality improvements. Production costs may actually be correlated with our measure of transport costs if intermediate inputs are imported or affected by the degree of import competition in final products. To the extent that transport costs differ across industries in their level and evolution over time and that plants use inputs from industries other than their own, the potential correlation with production costs seems limited. Nevertheless, we believe that our specification must include in the vector of controls proxies for production costs: average wages paid by the plant, the share of skilled labor in the plant's total workforce, unit prices paid for electricity by the plant, and the share of imported materials in total plant materials. Appendix 2 provides details on these four variables.

Third, omitted variables at the industry or plant levels correlated with import competition but also with product quality could bias the estimate of β_{TC}. The knowledge spillovers generated by FDI in an industry could drive plants, particularly those domestic-owned, to upgrade product quality. In this case omitting FDI from our

[77] We should note, however, that since unit values are serially correlated over time for plants, the use of lagged transport costs does not fully correct for potential reverse causality.

specification could bias downward the effect of import competition. However, higher FDI in an industry could also have a negative effect on quality upgrading by domestic-owned plants through market-stealing effects. In this case omitting FDI from our specification could bias upward the effect of import competition. Import competition may also be correlated with domestic competition in the industry. If stronger domestic competition in an industry has 'escape' effects as in Aghion et al. (2005), then it is likely associated with quality upgrading in that industry. Foreign exporters have an incentive to send to Chile products for which local substitutes have lower quality since it is easier to compete with those. Thus, omitting domestic competition from our specification could result in a negative link between import competition and product quality and a downward bias in the effect of import competition. To control for these possibilities, we include measures of FDI and domestic competition in the vector of controls: the share of total employment in the plant's main 4-digit industry accounted for by foreign-owned plants and the Herfindahl index for each of the 4-digit industries to which the plant's products belong.[78] Foreign-owned plants may produce higher-quality products and exhibit higher unit values relative to domestic-owned plants, regardless of import competition. The vector of controls includes a dummy for the plant's foreign ownership status to account for this possibility. That vector includes also an indicator for multi-product plants to acknowledge potential differences between multi-product and single-product plants.[79]

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[78] Since total employment of a plant is not allocated across the production of each of its products, the share of total employment accounted for by foreign-owned plants is computed for the plant's main 4-digit industry, which is for multi-product plants the industry to which the major product belongs. The major product accounts for the largest share (which could be less than 50%) of the plant's total sales.

[79] For example Bernard et al. (2006b) show that U.S. multi-product plants are significantly larger and more productive than single-product plants. The identification of the coefficient on the indicator for multi-product (*foreign-owned*) plants in our plant fixed effects estimation is based on plants that switch into multi-product status (*foreign ownership*) during the sample period.

Fourth, for any given product, quality differences may not fully explain the corresponding dispersion in unit values. Since unit values are prices, their increase may reflect to some extent an increase in a plant's market power. Moreover, plant size may play a role for quality upgrading by allowing the corresponding fixed costs to be spread over a larger scale and granting easier access to the financing necessary for upgrading, mimicking the role that size plays for radical innovation (Cohen, 1995; Cohen and Klepper, 1996). To address these possibilities, the vector of controls includes a measure of the plant's market share in each of the 4-digit industries to which its products belong and three size dummies based on the plant's total employment.[80]

Fifth, by including 3-digit industry-year fixed effects, we account for technological progress or other shocks experienced by Chilean industries during the sample period. In particular, these fixed effects may account for different trends in the prices of materials and capital goods faced by plants operating in different 3-digit industries which could affect the prices at which they sell their final products.[81]

Sixth, it is crucial to control for plant-specific unobservable heterogeneity by including plant fixed effects in Equation (1). Plants differ in the diversity of products they manufacture and in the type and quality of management which could affect their incentives and possibilities for quality upgrading. However, due to the presence of multi-product plants in the sample it is also crucial to control for product fixed effects in Equation (1) to ensure that β_{TC} is identified based on a comparison of unit values across

[80] The size dummies are defined in Appendix 2.

[81] IMF (2008) shows that the recent commodity price boom (with the exception of copper and oil) began only after the end of our sample period. Our year and industry-year fixed effects account for possible increases in the prices of copper and oil in the last two sample years which could have affected final products' unit values. Regarding oil, we also estimate Equation (1) for a sample excluding industries 353 (petroleum refineries) and 354 (manufacture of miscellaneous products of petroleum and coal) and find similar results relative to those discussed in Section 4.1.

plants producing the same product, as import competition changes. Moreover, product fixed effects account for physical or technological characteristics differentiating 7-digit products which may influence their unit values.

In sum Equation (1) allows us to identify an unbiased effect of import competition on product quality upgrading at the plant level due to the exogenous nature of transport costs and the set of control variables and fixed effects included.[82]

4. Results

4.1 Main Results

Table 3 presents the results from estimating Equation (1) with robust standard errors clustered by 4-digit industry and year considering all plants and products in Panel A.[83] To simplify the interpretation, TC_{it}^{k4} in Equation (1) measures the *negative* of transport costs: i.e., its increase corresponds to an increase in import competition whose quality upgrading impact is captured by a positive β_{TC}. All specifications include plant and product fixed effects, as well as year and 3-digit industry-year fixed effects. The estimates in column (1) show that import competition has a positive effect on product quality when plant cost controls, other plant characteristics, and industry characteristics are ignored. In column (2), the specification includes only plant characteristics in addition to transport costs. The estimate of β_{TC} is positive and significant and its

[82] Note that active innovation promotion programs may affect plants' incentives and possibilities to engage
in quality upgrading. However, our specification would need to account for such programs only if they targeted specific industries and could therefore be systematically correlated with import competition. The Chilean National Fund for Technological and Productive Development (FONTEC) - a public program in place since 1991 - helped finance innovation projects for manufacturing firms (Benavente et al., 2007). However, the program did not target specific industries within manufacturing.

[83] The significance of β_{TC} is maintained when standard errors are clustered by plant, product, or product-year.

magnitude increases. The difference in results across columns (1) and (2) suggests that in column (1) import competition may be picking up the effect of omitted plant characteristics negatively associated with quality. Columns (3) and (4) show the results from specifications where in addition to transport costs either only industry characteristics or only plant cost controls are included, respectively. The estimates of β_{TC} are positive, significant, and similar in magnitude to that in column (1) suggesting these factors do not substantially affect the results. Column (5) shows our preferred specification which includes the three types of controls.[84] The estimate of β_{TC} implies that a one percentage point reduction in transport costs would lead to an increase in log unit values of almost 2% within plants and products.[85] Since transport costs average 9.2% in our sample, a one percentage point reduction represents a meaningful increase in the degree of import competition faced by plants. Such reduction would correspond to the following important increases in actual unit values: e.g., (i) from an average of USD 86 to USD 93 for bicycles, (ii) from an average of USD 227 to USD 250 for domestic ovens and (iii) from an average of 16,454 USD to USD 19,735 for fabricated motor vehicles.[86]

While for brevity the tables do not report the estimated coefficients on the control variables included in our regressions, three findings are noteworthy. For a given product category, larger plants exhibit significantly higher unit values than smaller plants while multi-product plants exhibit significantly lower unit values than single-

[84] The control variables are contemporaneous relative to plant unit values. However, we obtain qualitatively similar results when one-year lagged control variables are included.

[85] Unit values are measured in logarithms and transport costs are measured in fractional terms, thus 1.9% is obtained by multiplying 1% by 1.887.

[86] These averages are for year 2000 and the unit values are expressed in USD using the corresponding average peso-USD exchange rate obtained from the Central Bank of Chile. Providing an economic magnitude for the average product is difficult due to the lack of comparability of unit values across products measured in different units.

product plants. Plants with larger market shares have significantly higher unit values, as expected. However, this market power effect does not eclipse the importance of increased import competition in generating quality improvements.

Panels B and C of Table 3 show the results from estimating Equation (1) for two different sub-samples. In Panel B, we use a sub-sample of all plants but only the products that plants neither start producing nor discontinue during their years in the sample (continued products). The effect of import competition on product quality is found to be positive, significant, and much larger than in Panel A. The difference in magnitudes suggests that products with less upgrading potential are likely to be discontinued by plants and new products are also less subject to upgrading as a result of import competition after their initial introduction. In Panel C, we use a sub-sample including only plants that are in the sample during the entire sample period (continuing plants) and including for each of those plants only their continued products. Import competition has a positive and significant effect on product quality, whose magnitude is even larger than in Panel B. This difference in magnitudes suggests that the 'well-established' products of continuing plants are more prone to quality upgrading as a response to increased import competition than the continued products of plants which just started operations or those of plants in their years shortly before exit.

4.2 Robustness

We conduct an extensive set of robustness tests to our preferred specification (column (5) of Panel A in Table 3).[87] First, we consider alternative criteria to eliminate

[87] For brevity, we show in what follows only the regression results corresponding to the full sample used in Panel A. However, the pattern detected across panels in Table 3 is also verified for our robustness and other regressions: i.e., the magnitude of β_{TC} is larger for the sub-sample of all plants but only continued

outliers in our dependent variable. Columns (1)-(4) of Table show the estimates of Equation (1) for four samples based on the following outlier criteria: excluding none of the observations (column (1)), excluding the top and bottom 10% of unit values for any product (column (2)), excluding observations with unit values above (below) the 75th (25th) percentile plus (minus) by 1.5 times the inter-quartile range (column (3)) or replacing those observations by those cut-off values (column (4)). The estimates show a significant positive effect of declines in transport costs on quality upgrading.[88]

A possible concern with our estimates is that the regressions give a larger weight to multi-product plants which have more observations per year than to single-product plants. To address this possibility, we follow the two-stage regression procedure proposed by Kugler and Verhoogen (2008). First, we regress plant unit values (the dependent variable in Equation (1)) on plant-year, product-year, and year fixed effects. For any given year, the estimated plant-year fixed effect provides an average plant unit value identified by the differences between a plant's unit value(s) and those of other plants producing the same product(s) in that year. Second, these time-varying average plant unit values are regressed on our transport cost measures along with 3-digit industry-year fixed effects.[89] In this regression a single-product plant and a multi-product plant included in the sample during the same number of years have equal weight. Column (5) of Table presents the results from this regression and shows that our main finding is qualitatively maintained.

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products (corresponding to Panel B) and even larger for the sub-sample of continuing plants and continued products (corresponding to Panel C). These results are available from the authors upon request.

[88] While we base our main results on the exclusion of outliers for product categories, qualitatively similar results are obtained when the exclusion of outliers is done for product-year categories.

[89] We refer the reader to Kugler and Verhoogen (2008) for further details on this two-stage procedure, in particular on the non-identification of some plant-year fixed effects.

Column (1) of Table 5 shows that the estimate of β_{TC} is robust to the addition of an indicator for the plant's exporter status which controls for possible unit value differences for exporters independent of import competition. Measuring competition in the domestic market is inherently difficult. Column (2) of Table 5 shows that the effect of import competition is robust to the use of the sum of the market shares of the 5 plants with the largest market shares in each of the 4-digit industries to which a plant's products belong as the measure of competition.[90] Moreover, within-country costs of transportation, among several other factors, may give plants in certain regions stronger market power. Hence, we show in column (3) of Table 5 the results from a specification where we add to our preferred specification regional Herfindahl indexes and market shares. Our estimate of β_{TC} remains qualitatively unchanged.

Table 5 also shows the results from three experiments to address potential reverse causality problems in our main specification. A first experiment consists of including in Equation (1) either the two-year or the three-year lag of transport costs. The results reported in columns (4) and (5) still show a positive and significant effect of lagged import competition on quality. A second experiment consists of modifying the definition of transport costs to exclude from the calculation of the weighted average country-product-year freight costs corresponding to import flows below 1,000 or 5,000 USD. The effects of import competition reported in columns (6) and (7) are still positive, significant, and are substantially higher than those in Table 3. This finding is reassuring with respect to the endogeneity concern discussed in Section 3, since import flows above

[90] In unreported regressions we also find robust effects of import competition when we replace the plant's market share in each of its 4-digit industries by that in each of its 5-digit or 6-digit industries, or in each of its 7-digit products. Results are available from the authors upon request.

5,000 USD are more permanent.[91] In the third experiment reported in column (8), we find our results to be qualitatively unchanged for an alternative measure based only on the freight rates for country-industry relationships lasting the entire sample period.[92] The evidence in columns (6) to (8) suggests that our decision to use information on freight costs for all import flows in our main specification is, if anything, underestimating the effect of import competition on product quality.

4.3 Unit Values and Quality

Increases in unit values seem to correspond well to the definition of incremental innovation in the OECD Oslo manual (1997) which covers "existing product[s] whose performance has been significantly enhanced or upgraded". For certain consumer products such as automobiles or washing machines, it is clear that higher prices are directly correlated with higher quality. This explains why various studies in the trade literature have taken for granted the idea that increases in export unit values represent improvements in quality (Fontagné and Freudenberg, 1997). The summary statistics on the heterogeneity in unit values presented in Table 1 support this argument. Industries with little scope for quality differences show low relative variation in unit values while industries where quality is expected to play an important role such as professional equipment (which includes information technology products) exhibit a much higher variability in unit values.

An extensive industrial organization literature has examined the role of product pricing as a signal for quality. The market for 'lemons' of Akerlof (1970) illustrates this clearly: in the presence of imperfect information, firms with high quality products need

[91] About 63 percent of those country-industry relationships last the entire sample period compared to 49 percent of the country-industry relationships corresponding to all import flows.

[92] Note that while the specifications in columns (6) to (8) provide a relevant robustness test, they could introduce a sample selection bias due to the omission of some country-year relationships.

to introduce signals - higher prices - to convey to consumers the high quality of their products. Fluet and Garella (2002) show theoretically that in markets with strong vertical product differentiation (i.e., those with substantial quality differences within product categories) firms may base their signaling on prices only.[93] Thomas et al. (1998) provide empirical evidence showing that higher prices are used for quality signaling purposes in the U.S. automobile industry. More broadly, this literature shows that prices are a good signal for quality since firms often choose intentionally their level as to reveal to consumers the higher quality of their products.

To provide further support that our estimates refer to product quality, we conduct different tests. Specifically, we examine whether the effects of import competition on unit values are stronger for industries whose product attributes (e.g., substitutability) suggest more opportunities for quality improvements or for plants whose actions or characteristics are likely to be associated with those improvements. We estimate a variant of Equation (1) given by:

$$\log UV_{it}^{p7} = \overline{\beta}_{TC1} * TC_{it-1}^{k4} * group1 + \overline{\beta}_{TCTL} * TC_{it-1}^{k4} * group2 + \gamma * X_{it} + I^{p7} + I_t + I^{m3} * I_t + f_i + \varepsilon_{it}^{p7} \quad (2)$$

where the effect of transport costs is allowed to differ across industries or plants belonging to group 1 and industries or plants belonging to group 2, and all other variables are defined as before. Column (1) of Table reports the results from estimating Equation (2) considering as group 1 (group 2) differentiated goods industries (non-differentiated goods industries) according to the classification proposed by Rauch

[93] The authors also show that in other scenarios, firms resort additionally to advertising as a signal for quality.

(1999).[94] The response to import competition is expected to be naturally larger in industries with a greater scope for quality differentiation. Our estimates show that the impact of tougher import competition on quality upgrading is indeed significantly larger for plants in differentiated goods industries.

In addition, product quality upgrading often requires substantial investments in physical capital by plants. Column (2) of Table shows the results from estimating Equation (2) defining group 1 (*group 2*) to include plants engaged in substantial (*low*) new investments relative to their capital stock. We assume that a substantial new investment relative to the capital stock - a ratio above 50% - represents the adoption of new technology by a plant, following Huggett and Ospina (2001). The estimates and the F-test show that the effect of import competition on unit values is significantly stronger for plants engaged in technology adoption.

Moreover, human capital is a key component of a plant's absorptive capacity to new technology and knowledge necessary for product quality upgrading (Cohen and Levintahl, 1989; Pack, 2006). Column (3) of Table shows the results from estimating Equation (2) defining group 1 (*group 2*) to include plants whose wage share of skilled labor in the first sample year is larger (*smaller*) than the sample median. The estimates and the F-test show that increased import competition leads to a significantly stronger increase in unit values for plants with larger skill shares. Overall, the findings in columns (1) to (3) provide evidence to support our assumption that increases in unit values are a good proxy for improvements in product quality.

[94] According to Rauch's classification, differentiated products are those that are neither (i) homogenous - traded in organized exchanges (e.g., steel) nor (ii) reference-priced - having listed prices in trade publications (e.g., some chemical products) and require a more important degree of buyer-seller interaction. To use Rauch's classification, we establish a correspondence between his 4-digit SITC rev. 2 codes and our 4-digit ISIC rev. 2 codes. For the printing industry (ISIC 342), we are unable to establish an unambiguous correspondence and thus drop it from the regressions using the industry groups 1 and 2 based on the Rauch classification

4.4 The Imports-as-Market-Discipline Hypothesis

A potential concern about our main results arises from the use of product prices as our plant-level outcome of interest. The imports-as-market-discipline hypothesis predicts a negative effect of import competition on price-cost margins (the ratio of the difference between price and marginal cost to price) of manufacturing plants, which might appear to be at odds with our results. To examine the effects of import competition on price-cost margins - which are not observable given that marginal costs are not observable - we follow the widely used methodology proposed by Roeger (1995). The methodology computes the difference between the primal Solow residual in the presence of imperfect competition (Hall, 1988) and the corresponding dual Solow residual derived from a cost function. This difference eliminates plant unobserved productivity which is associated with an endogeneity bias in production function estimation and results in an equation providing consistent estimates for price-cost margins.[95] We allow average price-cost margins to vary with the degree of import competition and with the degree of domestic competition faced by each plant in its main 4-digit industry.[96] Our estimable equation is given by:

$$\Delta Z_{it}^{k4} = \beta_1 \Delta X_{it}^{k4} + \beta_2 \Delta X_{it}^{k4} * TC_{it-1}^{k4} + \beta_3 \Delta X_{it}^{k4} * H_{it}^{k4} + \delta_1 TC_{it-1}^{k4} + \delta_2 H_{it}^{k4} + f_i + \eta_{it} \qquad (3)$$

where ΔZ_{it} and ΔX_{it} are computed based on the growth of plant nominal sales, wage bill, intermediate costs, and capital as described in Appendix 3, TC_{it-1}^{k4} is defined as before, H_{it}^{k4} is the Herfindahl index in 4-digit industry *k4*, f_i are plant fixed effects, and

[95] We refer the reader to Roeger (1995) and Konings et al. (2005) for details on the derivation of that equation.
[96] Plant level estimates of price-cost margins cannot be obtained due to insufficient degrees of freedom.

η_{it} is an i.i.d. residual.[97] The estimate of β_1 is the average price-cost margin while the estimates of β_2 and β_3 show how average price-cost margins differ depending on the degree of import and domestic competition, respectively.

The results from estimating Equation (3) by plant fixed effects are shown in Table with standard errors clustered by 4-digit industry and year. Columns (1) and (3) show that the average price cost-margins of Chilean plants are positively related to import competition. However, the effects are insignificant. In contrast, columns (2) and (3) show that average price-cost margins are positively and significantly linked to domestic competition. The estimated positive impact of import competition on price-cost margins may reflect increased market rents achieved by plants as a result of their incremental innovation to escape increased import competition. Since radical trade liberalization in Chile occurred in the early 1980s, it is not surprising that during our sample period the price-cost margins of Chilean plants were not disciplined by stronger import competition. Those pro-competitive price-lowering effects likely occurred much earlier. However, we should note that the absence of strong effects on price-cost margins does not weaken our evidence of quality upgrading since the increase in price-cost margins driven by higher prices charged for higher quality products may have been counteracted by the higher costs incurred by plants to achieve those quality improvements. If plants have to incur costs to signal the quality of their products, then these additional costs could equally explain why price-cost margins do not vary significantly with import competition.

[97] For comparability with the estimates of Equation (1) transport costs are lagged one year. However, the results are qualitatively similar including current transport costs or including all variables lagged one year.

5. Heterogeneity in the Impact of Import Competition

5.1 Does the Impact Differ by the Type of Exporting Country?

The evidence in Section 4 shows that import competition has on average a positive impact on product quality. A natural question that follows is whether increases in all types of import competition provide Chilean plants with incentives for quality upgrading. One of the advantages of our transport costs measure is that it is based on freight rate information for the countries of origin of all Chilean manufacturing imports. We can therefore distinguish import competition from technologically more advanced, richer, higher-wage countries from import competition from other countries. We estimate the following specification:

$$\log UV_{it}^{p7} = \overline{\beta}_{TCM} * {TC_{it-1M}^{k4}}^{moreadv} + \overline{\beta}_{TCL} * {TC_{it-1L}^{k4}}^{lessadv} + \gamma * X_{it} + I^{p7} + I_t + I^{m3} * I_t + f_i + \varepsilon_{it}^{p7} \qquad (4)$$

where transport costs measures are computed separately for more advanced countries ${TC_{it-1M}^{k4}}^{moreadv}$ and less advanced countries ${TC_{it-1L}^{k4}}^{lessadv}$ according to two country classifications, and all other variables are defined as in Equation (1). First, we define more advanced countries to be high-income and upper-middle income countries according to the World Bank's income group classification and report the results in column (1) of Table .[98] Second, we define more advanced countries to be countries whose scores in the Global Competitiveness Report's general country ranking are above

[98] We use the World Bank country classification as of April 2007 which establishes four income groups: low-income, lower-middle-income, upper-middle-income and high-income and covers all countries included in our transport cost dataset. The classification is based on gross national income per capita using the World Bank Atlas method. Upper-middle-income and high-income countries have an income level similar to or above that of Chile. We also estimate Equation (4) defining more advanced countries to be high-income countries and obtain qualitatively similar results.

the median score and report the results in column (2) of Table .[99] The estimates show that increased import competition from less advanced countries is the strongest stimulant for product quality upgrading by Chilean plants. The F-tests show that the difference in the effects across country groups is statistically significant for both classifications. These findings suggest that tougher competition from low-wage countries (including China and India) serves as an incentive for quality upgrading by Chilean plants and thus can be viewed as an advantageous type of competition. The products exported by more advanced countries to Chile may be too sophisticated for local plants to be able to 'beat' through quality upgrading. This finding provides support to the existence of a costly-to-overcome 'technology gap' that Cimoli and Correa (2002) argue has been responsible for lower growth benefits from trade liberalization in Latin America. Our evidence also support the hypothesis that the high cost of catching-up with more advanced economies in order to upgrade product quality may constitute a barrier to economic growth (Parente and Prescott, 1994).

5.2 Does the Impact Differ across Types of Plants or Types of Products?

An issue of interest is whether import competition affects product quality across all plants and all products equally or whether the effects are heterogeneous. First, we explore the possibility that plants which are less integrated into global markets may be affected differently by import competition. Table 9 shows the results from estimating

[99] The World Global Competitiveness Report (World Economic Forum, 2007) ranks 131 countries' performance based on a broad range of factors affecting a country's business climate: institutions, infrastructure, macroeconomic stability, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market, sophistication, technological readiness, market size, business sophistication, and innovation. Countries are ranked and given a performance score. We use the median score to divide our sample into above-median and below-median performers.

Equation (1) based on three restricted sub-samples of plants: including only non-exporting plants (column (1)), including only domestic-owned plants (column (2)), and including only domestic-owned plants which do not export (column (3)). The impact of import competition on product quality is positive and significant in all columns. Interestingly, the impact is substantially larger in magnitude for domestic-owned plants that do not export. This means that an increase in import competition elicits the strongest quality upgrading response from the plants that are less exposed to international competition through other channels such as exports or multinational parent linkages. A rationale for this finding is that plants that are more internationally integrated through exports or foreign ownership may already have been forced to undertake quality upgrading and increased import competition provides a weaker incentive for further upgrading.

Second, we examine whether plant size affects the strength of the impact of import competition on product quality. Column (4) of Table 9 shows the results from estimating Equation (2) defining group 1 (*group 2*) to include plants whose average total employment over the sample period is higher (*lower*) than the sample median.[100] Plant size is used as a rough proxy for plant performance and for whether a plant is a 'leader' i.e., it is closer to the technological frontier (of its industry or of the world) according to the terminology of Aghion et al. (2005, 2006). However, our F-test shows that the estimated effect of import competition does not differ significantly across plant size. This finding stands in contrast with those of Aghion and co-authors who show that leaders innovate more due to foreign competition than plants more distant from the technological frontier. The difference in findings could be simply due to the fact that

[100] The sample median employment is computed pooling across all plants and years. Note that the specifications still include three size dummies as control variables.

size is a poor proxy for a plant's distance to the technological frontier. Defining the distance to the technological frontier based on plant TFP measures would be closer to the strategy followed by Aghion et al. (2005, 2006) but we deliberately avoid pursuing that strategy due to the presence in our sample of many multi-product plants for which the usual measures of TFP can be biased (Bernard et al., 2005). Instead, we use an indirect approach to estimate heterogeneous impacts. We compute for each 7-digit product and year the absolute coefficient of variation in unit values (a measure of quality dispersion) and regress it on our transport costs measure. The results, reported in column (6) of Table 9 show a positive impact of import competition on product quality dispersion. This finding hints at the presence of heterogeneous impacts of competition on plants, possibly depending on their closeness to the technological frontier. The confirmation of this possibility cannot, however, be directly inferred from these results.

Column (5) of Table 9 shows the results from estimating Equation (2) defining group 1 to include products that are exported (at least partially) and group 2 to include products that are sold exclusively in the domestic market. Interestingly, the estimates and F-test show that the impact of increased import competition on quality upgrading is significantly higher for domestically sold products. It is possible that once these domestically sold products achieve sufficiently high quality, plants are able to sell them in export markets also, which is indeed the finding for Mexican plants by Iacovone and Javorcik (2008). This result points to the importance of using data both for domestically sold as well as for exported products to study the link between import competition and quality rather than data on exported products only.

6. Conclusion

So, does import competition affect product quality? We investigate this question using a rich dataset of Chilean plants and products and a regression framework where increases in unit values proxy for product quality improvements and transport costs are the exogenous measure of import competition. Our results show that import competition does have a positive, significant, and robust impact on product quality for Chilean plants. To the extent that these findings can be generalized to other middle-income countries, they suggest that increased exposure to import competition, including that from China and India, can be beneficial by encouraging their producers to follow the "high road" to competitiveness (Pietrobelli and Rabellotti, 2006). Moreover, in light of the evidence provided by Iacovone and Javorcik (2008) that Mexican plants invest in product quality upgrading before they export, our findings suggest that over time plants - including those with no export experience - may be able to progressively target more sophisticated export markets.

However, our evidence also suggests that import competition may be insufficient to enable quality upgrading where the "technology gap" between foreign competitors and local producers is high. In so far as quality upgrading for non-frontier products presents a less demanding task than more radical innovation, our findings suggest that while import competition encourages upgrading, other policy tools will be necessary for more radical innovations.

Our findings also suggest that the recent models of heterogeneous multi-product firms such as those of Bernard et al. (2006c) and Eckel and Neary (2006) that examine changes in firms' product mix as a response to trade costs' reductions have yet to exploit other interesting margins of adjustment such as the possibility of quality upgrading.

As was pointed out in Chapter 3, there are several shortcomings due to our measure of import competition. First of all, while transport costs might well measure import competition in Chile in firm product markets it is equally possible that it also captures several other effects. One telling example is that the measure will equally capture the obstacles to imports of production inputs for firms. We might actually measure impacts of improved access to production inputs and their impact on product quality rather than effects from competition. Also, we have implicitly assumed that a reduction on transport costs is equivalent to a unilateral trade liberalization that increases imports. However, reductions in the transport costs of imports into Chile may be correlated with reductions in the transport costs faced by Chilean exporters. Hence an alternative interpretation of the negative effect of transport costs on quality upgrading is that they reflect the effects of a symmetric increase in export market access and not those of product market competition. Verhoogen (2008) shows that such increase led to quality upgrading by Mexican firms.ory might rather be about lost learning opportunities than competition. These are important concerns that will require further analysis in order to strengthen findings reported here.

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Chapter 4: Tables

Table 1: Heterogeneity in Unit Values within Selected 4-digit Industries

4-digit ISIC		Coefficient of Variation
3111	Slaughtering, preparing and preserving meat	4.6%
3114	Canning, preserving and processing of fish, crustaces and similar	9.7%
3134	Soft drinks and carbonated waters industries	5.0%
3212	Manufacture of made-up textile goods	51.4%
3220	Manufacture of wearing apparel	81.9%
3312	Manufacture of wooden and can containers	37.2%
3420	Printing, publishing and allied industries	30.3%
3530	Petroleum refineries	5.5%
3620	Manufacture of glass and glass products	47.9%
3610	Manufacture of pottery, china and earthenware	22.9%
3692	Manufacture of cement, lime and plaster	7.4%
3831	Manufacture of electrical industrial machinery	34.6%
3844	Manufacture of motorcycles and bicycles	70.5%
3851	Manufacture of professional and scientific, and measuring and controlling equipment n.e.c.	86.6%
3901	Manufacture of jewellery and related articles	28.2%

Notes: The table shows for each 4-digit industry the simple average across all sample years of the industry's yearly coefficients of variation in unit values. For each 4-digit industry and year, the yearly coefficient of variation in unit values is obtained as a weighted average of the coefficients of variation in unit values for each of its 7-digit products using as weights the share of each 7-digit product in the 4-digit industry's total sales in the year.

Table 2: Transport Costs for Selected 4-digit Industries and Years

4-digit ISIC		1997	1999	2002
3112	Manufacture of dairy products	7.98%	6.46%	6.25%
3118	Sugar factories and refineries	10.67%	15.67%	14.02%
3212	Manufacture of made-up textile goods except wearing apparel	6.69%	7.74%	8.60%
3220	Manufacture of wearing apparel except footwear	4.98%	5.35%	5.13%
3312	Manufacture of wooden and cane containers and small cane ware	9.15%	6.29%	6.11%
3320	Manufacture of furniture and fixtures, except primarily of metal	13.72%	12.25%	13.98%
3122	Manufacture of prepared animal feeds	15.61%	12.91%	12.74%
3133	Malt liquors and malt	19.49%	12.61%	15.66%
3140	Tobacco manufactures	8.19%	8.46%	8.79%
3215	Cordage, rope and twine industries	4.33%	5.08%	6.39%
3233	Manufacture of leather and leather substitutes, except footware and wearing apparel	8.29%	9.85%	9.06%
3240	Manufacture of footwear, except vulcanised or moulded rubber and plastic footwear	5.20%	5.50%	5.81%
3412	Manufacture of containers and boxes of paper and paperboard	15.14%	10.52%	10.41%
3512	Manufacture of fertlizers and pesticides	11.21%	11.91%	10.95%
3551	Tyre and tube industries	7.95%	7.69%	8.25%
3560	Manufacture of plastic products not elsewhere specified	10.27%	10.04%	9.13%
3620	Manufacture of glass and glass products	13.49%	14.31%	13.84%
3720	Non-ferrous metal basic industries	4.64%	4.58%	4.06%
3822	Manufacture of agricultural machinery and equipment	6.51%	5.36%	6.21%
3831	Manufacture of electrical industrial machinery and apparatus	4.85%	4.63%	4.80%
3852	Manufacture of photographic and optical goods	3.36%	3.36%	3.85%
3420	Printing, publishing and allied industries	8.04%	8.74%	8.24%
3522	Manufacture of drugs and medicines	3.30%	3.07%	3.31%
3610	Manufacture of pottery, china and earthenware	11.85%	15.67%	13.97%
3710	Iron and steel basic industries	10.59%	10.06%	10.15%
3812	Manufacture of furniture and fixtures primarily of metal	12.20%	11.35%	12.94%
3813	Manufacture of structural metal products	9.80%	7.65%	8.05%
3844	Manufacture of motorcycles and bicycles	8.69%	10.56%	11.49%

Note: The table shows for each 4-digit industry transport costs aggregated from the level of the 8-digit HS code, exporting country, and year to the level of the 4-digit ISIC and year using as weights Chile's fob imports from each country and year.

Table 3: Effects of Transport Costs on Unit Values – Main Results

Panel A: Full Sample

	Dependent Variable: Log of Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	1.887**	1.891**	1.884**	1.881**	1.887**
	(0.750)	(0.750)	(0.740)	(0.750)	(0.730)
Plant Controls	No	Yes	No	No	Yes
Industry Controls	No	No	Yes	No	Yes
Plant Cost Controls	No	No	No	Yes	Yes
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	41032	41032	41018	40991	40981
R-Squared	0.56	0.56	0.56	0.56	0.56

Panel B: Sample of Continued Products

	Dependent Variable: Log of Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	3.897***	3.875***	3.788***	3.904***	3.788***
	(0.950)	(0.960)	(0.920)	(0.950)	(0.930)
Plant Controls	No	Yes	No	No	Yes
Industry Controls	No	No	Yes	No	Yes
Plant Cost Controls	No	No	No	Yes	Yes
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	18159	18159	18156	18138	18138
R-Squared	0.57	0.57	0.57	0.57	0.58

Panel C: Sample of Continuing Plants and Continued Products

	Dependent Variable: Log of Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	4.691***	4.639***	4.516***	4.680***	4.463***
	(0.980)	(0.990)	(0.930)	(0.980)	(0.940)
Plant Controls	No	Yes	No	No	Yes
Industry Controls	No	No	Yes	No	Yes
Plant Cost Controls	No	No	No	Yes	Yes
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	11762	11762	11762	11750	11750
R-Squared	0.59	0.59	0.59	0.59	0.59

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The negative of transport costs is included in the regressions. Plant controls include size dummies, a dummy for foreign ownership, a dummy for multi-product plants, and the plant's market share at the 4-digit level. Industry controls include the share of employment in foreign-owned plants in total 4-digit industry employment and the normalized Herfindahl index at the 4-digit industry level. Plant cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the plant, and the share of imported inputs in total inputs. The regressions in Panel B are estimated for the sub-sample of all plants but only products that the plant neither starts producing nor discontinues during its years in the sample while those in Panel C are estimated for the sub-sample of plants included in the sample during the entire sample period and for each of those plants only the products that they produce during the entire sample period.

Table 4: Effects of Transport Costs on Unit Values – Different Outlier Criteria and Weights

	Dependent Variable: Log of Unit Value				*Dependent Variable: Residual Log of Unit Value*
	Different Outlier Criteria for Unit Values				
	No Outliers Excluded	*Exclude Top/Bottom 10% of Unit Values by Product*	*Exclude Unit Values Based on Quartiles Criterion by Product*	*Windsorize Unit Values Based on Quartiles Criterion by Product*	*Second Stage Regression In 2-Stage Procedure*
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	1.917**	1.821**	1.745**	2.156***	5.119***
	(0.840)	(0.730)	(0.730)	(0.760)	(1.880)
Plant Controls	Yes	Yes	Yes	Yes	No
Industry Controls	Yes	Yes	Yes	Yes	No
Plant Cost Controls	Yes	Yes	Yes	Yes	No
Product Fixed Effects	Yes	Yes	Yes	Yes	No
Plant Fixed Effects	Yes	Yes	Yes	Yes	No
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	44157	36733	41929	44157	19546
R-Squared	0.5	0.59	0.58	0.57	0.32

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The negative of transport costs is included in the regressions. The samples used in columns (1) to (4) are described in the text. Plant controls in columns (1)-(4) include size dummies, a dummy for foreign ownership, a dummy for multi-product plants, and the plant's market share at the 4-digit level. Industry controls include the share of employment in foreign-owned plants in total 4-digit industry employment and the normalized Herfindahl index at the 4-digit industry level. Plant cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the plant, and the share of imported inputs in total inputs.

Table 5: Effects of Transport Costs on Unit Values – Robustness

	Dependent Variable: Log of Unit Value							
	Additional Plant Control	*Different Competition Measure*		*Alternative Lags for Transport Costs Measure*		*Alternative Transport Costs Measures*		
	Exporter Status	*Share of Top 5 Plants in 4-digit Industry*	*Adding Regional Competition Measures*	*Two-Year Lag*	*Three-Year Lag*	*Exclude Country-Product Import Flows below USD 1,000*	*Exclude Country-Product Import Flows below USD 5,000*	*Include Only Continued Country-4-digit Industry Import Flows*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Transport Costs $_{t-1}$	1.888**	1.955**	2.601***			3.336***	3.255***	3.937***
	(0.730)	(0.770)	(0.780)			(1.180)	(1.170)	(1.250)
Transport Costs $_{t-2}$				2.683**				
				(1.330)				
Transport Costs $_{t-3}$					2.765*			
					(1.440)			
Plant Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant Cost Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	40981	40734	38276	32387	24368	40947	40947	40834
R-Squared	0.56	0.56	0.57	0.56	0.57	0.56	0.56	0.56

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs, those in columns (6) to (8) include modified versions of that measure described in the text. Plant controls include size dummies, a dummy for foreign ownership, a dummy for multi-product plants, and the plant's market share at the 4-digit level., and a dummy for the plant's exporter status (only in column (1)). Industry controls include the share of employment in foreign-owned plants in total 4-digit industry employment and the normalized Herfindahl index at the 4-digit industry level (except in column (2) where the sales share of the largest 5 plants at the 4-digit level is included). Plant cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the plant, and the share of imported inputs in total inputs.

Table 6: Effects of Transport Costs on Unit Values – Evidence of Quality Upgrading

	Dependent Variable: Log of Unit Value		
	(1)	(2)	(3)
Transport Costs $_{t-1}$ * Dummy for Differentiated Product Industries	5.386***		
	(1.880)		
Transport Costs $_{t-1}$ * Dummy for Non-Differentiated Product Industries	1.304*		
	(0.760)		
Transport Costs $_{t-1}$ * Dummy for Large Investment-Capital Ratio		2.591***	
		(0.860)	
Transport Costs $_{t-1}$ * Dummy for Small Investment-Capital Ratio		1.698**	
		(0.700)	
Transport Costs $_{t-1}$ * Dummy for Firms with Higher Skilled Share			2.702***
			(0.710)
Transport Costs $_{t-1}$ * Dummy for Firms with Lower Skilled Share			1.740**
			(0.820)
Plant Controls	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes
Plant Cost Controls	Yes	Yes	Yes
Product Fixed Effects	Yes	Yes	Yes
Plant Fixed Effects	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes
P-value for F-Test of Difference in Coefficients across Groups	0.04	0.04	0.08
Number of Observations	39296	40981	37343
R-Squared	0.56	0.56	0.57

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The regressions include the negative of transport costs interacted with alternative sets of dummy variables described in the text. The plant controls, industry controls, and plant cost controls included in the regressions are similar to those in column (5) of Panel A of Table 3.

Table 7: Effects of Transport Costs on Price-Cost Margins

	Dependent Variable: ΔZ_t (in Equation (3))		
	(1)	(2)	(3)
ΔX_t	0.506***	0.454***	0.492***
	(0.029)	(0.016)	(0.029)
ΔX_t* Transport Costs $_{t-1}$	0.417		0.413
	(0.340)		(0.324)
ΔX_t* Herfindahl Index $_t$		0.178**	0.177**
		(0.084)	(0.081)
Plant Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Number of Observations	18282	18282	18265
R-Squared	0.42	0.42	0.42

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The computation of the dependent variable ΔZ_{it} and of ΔX_{it} is described in Appendix 3. In columns (1) and (3) the negative of transport costs is included in levels and interacted with ΔX_{it} .

Table 8: Effects of Transport Costs on Unit Values – By Type of Country

	Dependent Variable: Log of Unit Value	
	(1)	(2)
Transport Costs $_{t-1}$ from More Advanced Countries WB	0.639	
	(0.720)	
Transport Costs $_{t-1}$ from Less Advanced Countries WB	3.381***	
	(0.900)	
Transport Costs $_{t-1}$ from More Advanced Countries GCR		-0.273
		(0.670)
Transport Costs $_{t-1}$ from Less Advanced Countries GCR		3.362***
		(1.030)
Plant Controls	Yes	Yes
Industry Controls	Yes	Yes
Plant Cost Controls	Yes	Yes
Product Fixed Effects	Yes	Yes
Plant Fixed Effects	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes
P-value for F-Test of Difference in Coefficients across Country Groups	0	0
Number of Observations	40947	40907
R-Squared	0.56	0.56

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. Column (1) includes the negative of transport costs for high income and upper-middle income countries and for lower-middle income and low income countries according to the World Bank country specification. Column (2) includes the negative of transport costs for countries with a performance score above the median and for countries with a performance score below the median, according to the Global Competitiveness Report. The plant controls, industry controls, and plant cost controls included in the regressions are similar to those in column (5) of Panel A of Table 3.

Table 9: Effects of Transport Costs on Unit Values – By Type of Plant or Product

	Dependent Variable: Log of Unit Value					*Dependent Variable is Coefficient of Variation in Unit Values*
	Excluding Plants with International Ties					
	Sample of Non-Exporting Plants	*Sample of Domestic Plants*	*Sample of Domestic Non-Exporting Plants*			
	(1)	(2)	(3)	(4)	(5)	(6)
Transport Costs $_{t-1}$	3.529***	1.924**	3.784***			0.617***
	(0.850)	(0.760)	(0.900)			(0.140)
Transport Costs $_{t-1}$ * Smaller Plants Dummy				1.681***		
				(0.640)		
Transport Costs $_{t-1}$ * Larger Plants Dummy				1.506**		
				(0.690)		
Transport Costs $_{t-1}$* Exported Products Dummy					0.887	
					(0.780)	
Transport Costs $_{t-1}$* Non-Exported Products Dummy					2.089***	
					(0.730)	
Plant Controls	Yes	Yes	Yes	Yes	Yes	No
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes
Product Cost Controls	Yes	Yes	Yes	Yes	Yes	No
Product Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
P-value for F-Test of Difference in Coefficients across Groups				0.61	0	
Number of Observations	31309	38500	30411	40981	40981	3737
R-Squared	0.6	0.57	0.6	0.56	0.56	0.14

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. All regressions include the negative of transport costs, those in columns (4) and (5) include that variable interacted with alternative sets of dummy variables described in the text. The plant controls, industry controls, and plant cost controls included in the regressions are similar to those in column (5) of Panel A of Table 3.

Appendix

1. Examples of 7-Digit Products for Selected 4-digit Industries

4-digit ISIC		7-digit ISIC	Product Description	Unit of Measurement	Average Annual Unit Value Changes
3117	Manufacture of bakery products	3117101	Bread of any kind, size and quality (except sweet bread)	in tons	2.89%
		3117201	Cookies, with and without sugar and filled	in tons	4.28%
		3117301	Noodles, pasta including macaroni	in tons	0.22%
		3117402	Mixed dough (for different types of cakes)	in tons	-11.42%
3311	Sawmills, planing and other wood mills	3311307	Finished parquet excluding plastic parquet	in square meters	1.28%
		3311302	Wooden boards for prefabricated houses	in square meters	-13.16%
		3311306	Wooden doors with or without glass	in units	0.10%
		3311124	Sawing wood	in cubic meters	5.94%
3320	Manufacture of furniture and fixtures, except primarily of metal	3320908	Sofas and armchairs of the type used in ceremonies	in units	31.79%
		3320910	Wooden tables for computers and typewriters	in units	10.08%
		3320906	Wooden household furniture	in units	26.47%
		3320913	Office furniture	in units	-5.45%
3483	Manufacture of motor vehicles	3843201	Fabricated motor vehicles	in units	0.41%
		3843409	Wheels and related parts and vehicle accessories	in units	5.78%
		3843421	Heating appliances for motor vehicles	in units	-2.68%
		3843422	Metallic frames for trucks, special frames	in units	19.27%
3559	Manufacture of rubber products n.e.c.	3559324	Gloves of caoutchouc	one pair	13.63%
		3559327	Sports shoes	one pair	5.51%
		3559320	Caoutchouc sheating for mining	in tons	17.00%
		3559332	Articles made of caoutchouc for vehicles	in tons	26.81%
3829	Machinery and equipment except electrical n.e.c.	3829056	Cablecars	in units	20.74%
		3829032	Gas regulators	in units	-4.56%
		3829060	Moving staircases	in units	26.01%
		3829002	Pumps for liquids for manual use	in units	13.71%

Notes: For each 7-digit product and year, we compute the average logarithmic unit value by pooling across all plants that manufacture that product. Then across any two consecutive years we compute the difference in average log unit values to obtain the annual change in unit values. The statistic in the table shows the simple average of those annual changes.

2. Data Issues

2.1 Plant and Products Data

We combine a products dataset at the 7-digit level for the period 1997-2003 and the annual manufacturing census of Chilean plants with more than 10 employees (ENIA) for the same period. As described in Chapter 2 the ENIA includes some plants with discontinuous data over the sample period. For those plants, we consider only the observations across consecutive years for which yearly growth rates of any variable can be computed. In the products dataset, products are identified by a classification based on ISIC Rev. 2 and Rev. 3. More detail on the products data is provided in Navarro (2008). We obtain products at the 7-digit level building up from what Navarro (2008) refers to as 'ENIA products'. Specifically, for each plant reporting more than one entry for a 7-digit product in a given year (Z entries) we sum the information on sales values and product quantities of those Z entries for that plant as long as all the Z entries' quantities are reported in the same unit. The sum provides us with a single entry for that 7-digit product for that plant in that year. If the entries' quantities are reported in multiple units, we drop those products from the analysis. Note that these deletions occur in a very small number of cases. Also note that if aggregated to the 4-digit level, our 7-digit products correspond exactly to the United Nations product classification.

For our analysis, we use information on sales values and product quantities sold for each 7-digit product, plant, and year. We exclude from the final sample (i) plants that do not report the measurement unit for their products' quantities and (ii) plants that report their products' quantities in a different unit than the unit in which the majority of plants report. We also exclude from the sample the top and bottom 5% of the unit values' distribution for any 7-digit product. After applying these data cleaning procedures our final sample includes 55,294 plant-year-product observations.

We test the goodness of our products data by identifying plants with irregular product 'drops' (i.e., products that disappear from production and then reappear again) and plants with product 'jumps' (i.e., products that are produced only once in the intermediate years of plant presence in the sample). These tests, which follow Bernard et al. (2008), are satisfactory in that product 'drops' and product 'jumps' are relatively infrequent. We also perform another test which compares the standard deviations of 'purged' unit values for 4-digit industries with the same standard deviations obtained for a Colombian products dataset by Kugler and Verhoogen (2008). 'Purged unit values' are the residuals from regressions of log unit values on product fixed effects or from regressions of log unit values on product-year fixed effects. Our standard deviations are somewhat larger than theirs but are sufficiently within bounds to be explained by the fact that we consider a different country with a distinct profile of manufacturing production.

We use variables from the ENIA census to compute the proxies for costs of production included in our regressions. Plant average wages are obtained as the ratio of total wages paid to the plant's employees. Plant skill share is defined as the ratio of the number of skilled workers (a sum of managers, administrative personnel and qualified production workers) to the total number of workers employed by the plant. Plant electricity unit prices are computed as the log of the ratio of electricity expenditure to the quantity of electricity purchased. To eliminate outliers in each of these variables, we follow a 'winsorizing' procedure whereby we replace the top and bottom 5th percentile of observations in each year by the value of the cut-off observations at the 5th and 95th percentile in that year, respectively. Plant share of imported materials is computed as the ratio of the expenditure in imported materials and primary inputs to the overall expenditure in materials and primary inputs. The three size dummies are defined based on total employment: small plants have less than 50 employees, medium plants have 50 to 200 employees, and large plants have more than 200 employees.

2.2 Transport Costs Data

We use a transport costs dataset from the ALADI secretariat for the period 1997-2003 that includes the freight value (excluding insurance costs) and the free on board customs value (fob) of Chilean imports for each 8 digit HS code, exporting country, and year. For each 8-digit HS code, exporting country, and year we compute a freight rate as the ratio of the freight costs to the fob imports. We remove observations with higher freight costs than their fob import value for values below 1,000 USD. Our measure of transport costs is given by a weighted average of the freight rate aggregated from the level of the 8-digit HS code, exporting country, and year, to the level of the 4-digit ISIC and year using as weights Chile's fob imports from each country and year. To convert import flows between 8-digit HS codes and 4-digit ISIC codes we use a correspondence obtained from http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html. Our dataset includes all Chilean imports originating in 169 countries. Taking the overall value of imports for the entire period 1997-2003, the top 10 exporters to Chile are the United States, Brazil, Argentina, China, Germany, Japan, France, Mexico, South Korea, and Italy.

3. Methodology and Data Issues for Price-Cost Margins

The difference between the primal Solow residual and the corresponding dual Solow residual derived from a cost function results in the equation below which follows Konings et al. (2005):

$$\left(\frac{\Delta Y_{it}}{Y_{it}}+\frac{\Delta P_{Y\,it}}{P_{Y\,it}}\right)-\alpha_{Lit}\left(\frac{\Delta L_{it}}{L_{it}}+\frac{\Delta P_{L\,it}}{P_{L\,it}}\right)-\alpha_{Mit}\left(\frac{\Delta M_{it}}{M_{it}}+\frac{\Delta P_{M\,it}}{P_{M\,it}}\right)-(1-\alpha_{Lit}-\alpha_{Mit})\left(\frac{\Delta K_{it}}{K_{it}}+\frac{\Delta P_{K\,it}}{P_{K\,it}}\right)$$
$$=\beta_{it}\left[\left(\frac{\Delta Y_{it}}{Y_{it}}+\frac{\Delta P_{Y\,it}}{P_{Y\,it}}\right)-\left(\frac{\Delta K_{it}}{K_{it}}+\frac{\Delta P_{K\,it}}{P_{K\,it}}\right)\right] \tag{A1}$$

where β_{it} is the price-cost margin for plant *i* in year *t*, $\left(\Delta Y_{it}/Y_{it}+\Delta P_{Y\,it}/P_{Y\,it}\right)$ is nominal sales growth, $\left(\Delta L_{it}/L_{it}+\Delta P_{L\,it}/P_{L\,it}\right)$ is wage bill growth, $\left(\Delta M_{it}/M_{it}+\Delta P_{M\,it}/P_{M\,it}\right)$ is intermediate costs growth, $\left(\Delta K_{it}/K_{it}+\Delta P_{K\,it}/P_{K\,it}\right)$ is capital stock growth, and α_{Lit}, α_{Mit} are labor and intermediates shares in total nominal sales. Equation (A1) assumes constant returns to scale: $(1-\alpha_{Lit}-\alpha_{Mit})$ is the cost share of capital. To reach Equation (2) in the text we designate the left hand side of Equation (A1) by ΔZ_{it}, and the right hand side parentheses term by ΔX_{it}, we interact ΔX_{it} separately with the transport costs measure and with the Herfindahl index, we include in Equation (A1) the transport costs measure and the Herfindahl index levels as well as year fixed effects and we add an i.i.d. stochastic residual η_{it}. Equation (2) in the text is estimated for the sample of plants in the ENIA dataset during the 1997-2003 period. For plants with discontinuous data we include only the observations across consecutive years for which yearly growth rates of variables can be computed. The sample differs from that used for the unit values regressions since the observations are dropped based on the following criteria: (1) we exclude from the sample plants with missing sales, wage bill, intermediate costs, or capital variables; (2) we impute sales, wage bill, intermediate costs, or capital to correct for non-reporting by a plant in a single year (which occurs in fewer than 30 plant-year observations); (3) we exclude from the sample plants whose sales growth, wage bill growth, or capital growth is larger than (smaller than) 400%; (4) we exclude from the sample plants whose sales (wage bill) growth ranges between 100% and 300% (-300% and -100%) but is not accompanied by corresponding high (low) growth rates of intermediate costs (total employment). After applying these data cleaning procedures our final sample includes 31,318 plant-year observations.

To compute ΔZ_{it} and ΔX_{it}, we use plant-level information on nominal sales and on total wage bill and compute their corresponding logarithmic growth rates. Nominal intermediate costs are obtained as the sum of materials costs and electricity costs and the corresponding logarithmic growth rate is calculated. Capital stocks are computed using the perpetual inventory method (PIM) as described in Chapter 2 and the corresponding logarithmic growth rate is computed. We define the rental price of capital to be equal to the product of the aforementioned investment goods price deflator and the sum of the real interest rate and a depreciation rate as in Konings et al. (2005). Similarly, data on the lending interest rate and the consumer price index taken from the IMF financial statistics is used to compute the real interest rate. The depreciation rate used is the simple average of the rates used in Chapter 2 for three types of capital goods: 3% for buildings, 7% for machinery and equipment, and 11.9% for transport equipment. Using an alternative depreciation rate equal to 10% provides almost similar results. The share of labor (*intermediates*) in sales is given by the ratio of the wage bill (*intermediate costs*) to total nominal sales.

Chapter 5: Technology vs. Trade
What Explains Relative Wage Changes in Chile?

Abstract

This chapter analyses the effects of trade and technological change on the decrease in wage inequality in the Chilean manufacturing sector for the 1996 -2003 period. We establish the impact of trade by means of regressing product price changes on production cost shares of skilled and unskilled labour as well as capital. We do the same analysis for technological change which is measured by total factor productivity growth. A novelty of our analysis is that we conduct that analysis both at firm and industry levels. We find that technological change rather than trade explains the decrease in relative wages.

Keywords: wage inequality, trade, technological change, Chile

JEL Classification Codes: F16, J31, O33, L60

1. Introduction

The Chilean economy has been open to trade well before other Latin American economies (Moreira and Blyde, 2006). Trade openness had significant positive impacts on the economy including productivity gains and product upgrading as discussed in Chapters 3 and 4. However, it apparently did not have a positive impact on income inequality since income inequality hardly changed from the late 1980s to the 1990s (Bravo and Marinovic, 2001, World Bank, 2000). Wage differences between skilled and unskilled workers in the manufacturing sector were also persistently high over the same period. However, we find that there was a significant decrease in wage inequality over the 1996 – 2003 period. Given the high level of wage inequality in Chile and Latin America as a whole it is the more so important to investigate what factors contributed to this reduction in the Chilean case. The simple question we ask in this chapter is to what extent this recent trend in relative wages can be explained by effects of trade and technological change.

There has been a lot of empirical work on this topic in the empirical literature,[101] but only few analyses have evaluated the relative contributions of both trade and technological change to wage inequality within a single theoretical set-up. We base our empirical work on a model proposed by Leamer (1998) that offers such a framework. The key characteristic of this model is that it situates the discussion of relative wages in a multi-sector model where labour is flexible across sectors. The contributions of both trade and technological change on relative wages will depend on the potential sectoral bias of those changes and resulting effects on the profitability of sectors. If, to give an example, the profitability of some sectors increased there would be an inflow of labour

[101] References are provided in section 2 of this chapter.

in order to restore the zero-profit condition of perfect competition. As sectors differ in their relative use of skilled and unskilled labour the relative demand for both factors would be affect with consequences for relative wage payments. An important conclusion is, therefore, that the effect of technological change depends on its sector-bias and cost-reduction potential rather than whether it is skill-biased or not.

The empirical strategy we implement follows directly from the theoretical framework. We make use of a rich dataset on Chilean firms and their products for 1996 and 2003 and implement two regressions to establish the firm/sector biases of changes in trade and technology. First, we regress price changes from 1996 to 2003 on the cost shares of skilled and unskilled workers as well as capital. Second, we do the same analysis for technological change proxied by TFP growth from 1996 to 2003 on cost shares. The estimated coefficients on the cost shares of wages are 'mandated' wage changes by sector biases of technological and price changes. Studies using this methodology (e.g. Haskel and Slaughter, 2001 and Gregory and Zissimos, 1999) were conducted exclusively at rather aggregate industry levels as more disaggregate industry price indices were not available. The question of the correct level of aggregation is, however, an important aspect. The model relies on heterogeneity across sectors in terms of their different factor intensities and the implicit assumption is that each industry sector regroups firms with the same input factor intensities. If too broadly defined industries are chosen, it may be that each industry includes firms with very diverse factor intensities so that aggregate factor intensities are in fact misleading. Our contribution consists in verifying that such problems of aggregation do not affect results. We do that in implementing the analysis at the level of the 4- and 3-digit ISIC industry classification as well as at the plant level. Moreover, ours is the first analysis to do this type of analysis in the context of an emerging economy.

We find consistently across all three specifications that technological change rather than trade explains the decrease in relative wages. At least for our data we can exclude the possibility that aggregation drives industry-level results. Our evidence is not inconsistent with evidence that documents the importance of skill-biased technological change, but shows that cost-reducing technological change was concentrated in unskilled-intensive sectors so as increase relative unskilled wages. Results are robust to the exclusion of potentially influential outliers. Notwithstanding, there are a couple of caveats to our findings that are discussed in the concluding section.

Following the introduction, the paper describes income inequality in Chile and the existing literature on the topic (section 2). This is followed by a detailed discussion of the "mandated wage equations" methodology and its theoretical underpinnings (section 3). Next, in section 4 we briefly describe the data and how firm-level output prices are obtained. We will then present results and interpret them in light of the existing evidence (section 5). Finally, section 6 concludes.

2. Existing Evidence on Wage Inequality

2.1 Wage Inequality in Chile

We find there is a decrease of wage inequality in the manufacturing sector in Chile over the period 1997 – 2003. Figure 1 documents well the decrease in relative wages.[102] This is a very interesting finding since there have been no significant improvements in wage inequality in Chile from the end of the 1980s and for most of the

[102] Appendix Table 1 shows relative wages for skilled and unskilled labour and further data both for the entire sample and for the restricted sample that is analysed.

1990s.[103] The evidence is the same whether one uses information from the Chilean Household Surveys (CASEN) or the Manufacturing Firm Census (ENIA) we will rely on in this study.[104] This is the more so striking since Chile has one of the highest levels of income inequality in Latin America, a region with very high levels of income inequality that are only exceeded in Sub-Saharan Africa (World Bank, 2003). The lack of a more equitable distribution of the gains from substantial economic growth in Chile has in fact been one of the big shortcomings of an otherwise impressive performance and the persistence of inequality is a major issue of political debate (The Economist, 2007). Explaining the causes of the decrease in wage inequality is, therefore, an important topic.

2.2 Evidence on the Causes of Wage Inequality

Wage inequality in the United States increased significantly in the 1980s and 1990s. Similar changes took place in the United Kingdom in the 1980s (Katz and Autor, 1999). The initial evidence has been the beginning of a huge literature that documents the features of wage inequality in OECD countries and discussed its causes. Three main explanations emerged from this literature attributing increased wage inequality to the effects of (i) trade, (ii) skill-biased technological change (SBTC) and (iii) changes in labour market institutions.[105] These have frequently been analysed separately.[106] Studies

[103] Bravo and Marinovic (2001) and World Bank (2000) among many others provide statistical evidence.

[104] Unreported comparisons of our dataset with the Chilean household survey (CASEN) suggest that the ENIA picks up a smaller proportion of high income earners. This is intuitive since firm owners are not included in relative wage statistics which includes managers, qualified production workers and administrative staff in the group of skilled workers and unqualified production and non-production workers as well as support staff as unskilled workers.

[105] Katz and Autor (1999) provide a useful overview on trends, theory and evidence for the United States and some other OECD countries. Acemoglu (2002) provides a useful review of research on SBTC in OECD countries. Note that since we focus on the trade versus technology debate studies on the contribution of labour institutions will be left out of the discussion.

[106] See e.g. Deardorff (2005) on the trade hypothesis and Acemoglu (2002), Card and DiNardo (2002) on the SBTC hypothesis. The literature reviews provide a full list of the related literature.

for developing countries focused mainly on documenting the skills impacts following trade liberalisation.[107] Only few of these look at the technological change hypothesis.[108]

A few papers analyse the roles of trade and technology in Chile. Gallego (2006) assesses the importance of technology on wage inequality.[109] The results of this study point to the importance of technical change to account for higher wage inequality. Beyer et al. (1999) and Robbins (1994) find evidence that trade had a negative impact on inequality for an earlier period. [110]

These studies do not try to establish the relative contributions of both technology and trade despite the fact that both effects are likely interlinked. Bustos (2005) presents a model and shows some evidence that trade liberalisation may increase the profitability of new technologies in less developed countries. Hence, trade may lead to increased wage inequality if, for instance, skill-biased technologies are adopted as a result.[111] Even in the absence of such an obvious relationship between trade openness and technological change, both factors are likely to simultaneously impact relative wages and it is, therefore, desirable to analyse both jointly. An approach aiming at reconciling both approaches – the one focusing on trade and the second on technological change - was first developed by Leamer (1998). Haskel and Slaughter (2001) used it to understand relative contributions of trade and technology to increased UK wage inequalities. The results, summarised in Haskel (2000), suggest that in the US both trade and technology

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[107] Section 3.2. in Pavcnik and Goldberg (2004) gives an overview of these studies.

[108] Fajnzylber and Fernandes (2004) provide an interesting study on this topic. They analyse plant-level data for Brazil, China and Malaysia and find evidence that for all countries foreign direct investment (FDI) and technology licensing were correlated with more skilled-labour demand, which they interpret as possibly related to diffusion of skill-biased technology from developed countries.

[109] His strategy is similar in spirit to that of Berman and Machin (2000).

[110] Note that two other papers by Pavcnik (2003) and Fuentes and Gilchrist (2005) proceed to analyse the joint effect. However, their analysis relies on a variable, labelled in the survey as 'patentes y derechos municipales'. Despite the similarity in name the latter does not refer to patents. Therefore, the results of studies cannot be used as a comparison.

had an impact on increased wage inequality (Feenstra and Hanson, 1999). For the UK, by contrast, technological changes do not seem concentrated in skill-intensive sectors.

2.3 Wage Inequality in Light of the Macroeconomic Context

It is useful to consider regulatory changes and the macroeconomic context to frame our analysis. First of all, the discussion in Chapter 1 illustrates that the period we analyse here is a period of strong economic growth largely shared by a corresponding growth in manufacturing value-added interrupted only the spillover effects of the Asian crisis. As technological change is an important explanation for growth, this strongly suggest that such changes took place over the period of analysis. Also, there was an increase in imports with potential effects on relative product prices.

Focusing on the labour market more specifically Chapter 1 shows that there was constant employment growth between 1987 and 2006. This is clearly not consistent with the assumption of fixed labour supply of our theoretical model (as described in the following section). For the 1997 – 2003 period we study here the growth rate is positive and of about 7%. Depending on the skills composition of those new employees this might have some effect we are do not address in this study given the confines of our theoretical model.

Another aspect discussed in the introduction that could be highly relevant for our analysis is the increase in real minimum wages due to the economic slowdown. However, the onset of the decrease in relative wages happens after the increase in minimum wages that started in 1998. Moreover, the study by Infante et al. (2003) suggests that minimum wages were not very effective as the outcome was an increase in informal wage contracts allowing firms to pay lower wages than those imposed by regulation. Notwithstanding, a formal study on the impacts of the rise in minimum wages on relative wages would be useful to understand whether they had some effect on wage inequality.

3. Methodology

3.1 Mandated Wage Equations

The theoretical background of the "mandated wage approach" is outlined in detail by Haskel (2000). We will, therefore, merely highlight the basics of the model so as to motivate our empirical contribution and for the interpretation of our findings. The main reason why we have chosen to use this methodology is because it seeks to understand the relative contributions of international trade *and* technological change to relative wage movements. This is a particularly attractive feature, because it is possible to evaluate their contribution and give quantitative estimates of the effects of both on relative wages. Furthermore, the empirical framework is also useful since its theoretical framework is an extension of the Heckscher-Ohlin model, and, therefore, lends itself to straightforward interpretation once results are obtained.

The key insight of the multi-sector model characterising the mandated wage equations approach is that none of the evidence on skill-biased technical change within one sector would give conclusive evidence that SBTC explains relative wage changes. This is because relative wages depend on whether technical progress and output prices are changing by more in one sector relative to another. The differences in technological progress across sectors (with differently skill-intensive production technologies) are what matters.

The following is a useful illustrative example: Consider an increase in skilled-labour supply to the economy. In a one-sector model, the economy can absorb the extra skilled labour only through wage changes. In a multi-sector model, by contrast, sectoral output can change, as well. A combination of higher output in the skill-intensive sector and lower output in the unskilled-intensive sector can potentially absorb the rise in skilled supply (a Rybczynski effect). No relative wage change would be necessary. Therefore, the economy-wide labour-demand curve, in a multi-sector model, reflects both these output mix changes and relative wage changes.

3.2 The Basic Framework

The theory assumes there are several heterogeneous zero-profit industries so that revenue equals cost; so for sectors *i* and *j* we have:

$$\begin{aligned} p_t^i Y_t^i &= C_t^i = c(w_{s,t}, w_{u,t})^i Y_t^i \\ p_t^j Y_t^j &= C_{t^t}^j = c(w_{s,t} w_{u,t})^j Y_t^j \end{aligned} \tag{1}$$

where *p* are prices, *Y* is output and *C* are total and *c* marginal production costs of sectors *i* and *j*. All workers are considered mobile across sectors and, therefore, each sector faces a flat relative labour supply curve and wages w_s and w_u are the same across sectors. The pool of skills available in the workforce is taken to be fixed. Equation (1) implies that price is equal to marginal cost.

Applying logarithms to equation (1), totally differentiating with respect to time and using Shephard's lemma, the changes in (log) relative wages can be written as follows:

$$\Delta \ln(w_s / w_u) = \frac{1}{V_i^s - V_j^s}\left[\Delta \ln(p_i / p_j) + \Delta \ln(TFP_i / TFP_j)\right] \tag{2}$$

where V_i^s and V_j^s are shares of skilled labour in the total wage bill, *TFP* is total factor productivity and *p* are prices in industry sectors *i* and *j*. Note that we assume that $V_i^s > V_j^s$. Skilled and unskilled wages are not indexed because there is free mobility of workers across sectors. Hence, there will only be one price for each type of labour in the economy. Let us imagine here that industry *i* is more skill-intensive than industry *j*. The equation (1) shows that changes in total factor productivity or prices may affect relative wages. For both variables their relative impacts across sectors and not the magnitude of their effects within single sectors matters for the determination of relative wages.

The explanation for this is as follows taking the example: If technological change is more important in skill-intensive sectors than in less skill-intensive sectors, the former will generate more profits than the latter. Available profit opportunities generate incentives to shift more production to skill-intensive sectors. This generates a relative increase in the economy's demand for skilled workers. If the supply of skilled workers is fixed, there will be an increase in their relative wages. This increase will continue up to the point where the rise in relative wages has driven positive profits in the skill-intensive sectors back down to zero. The opposite would happen if this had happened in less skill-intensive sectors. Note that technological progress itself does not have to be skill-biased in order to affect relative wages in this set-up. It could be that it improves productivity of both types of labour, but if it is relatively more important in the skill-intensive sector it would still affect relative wages as described before.[112]

3.3 Empirical Specification

The empirical strategy that follows this framework, therefore, consists in regressing changes in product prices and TFP for different sectors on cost shares of production inputs. We use product price changes to indicate trade-induced changes in

[112] Changes in prices across industries may also have an impact on relative wages. The impact depends on relative changes across different sectors. If prices fall in a specific sector, the zero-profit condition no longer holds. Firms in that industry will make negative profits. As a consequence, there will be a shift in the economy's production towards other products. Assume this happens in the skill-intensive industry. There will be a boom in the non-skill-intensive sector. The relative demand for unskilled workers rises and, as a consequence, their relative wage. The extent of the wage increase until the fall in relative wages of skilled workers has restored the zero-profit condition in the skill-intensive sector.

relative wages. This is because, according to theory, trade will affect product prices. TFP is our measure of technological change since it incorporates all types of efficiency improvements with cost-reducing potential rather than specifically skill-biased or skill-neutral technological changes only. The estimated coefficients on the cost shares of wages are 'mandated' wage changes by sector biases of technical and price changes. If zero profit conditions have to be restored in all sectors after price and technology changes, these are the necessary wage changes.[113] Thus, the basic empirical specification is given by the following equation:

$$\Delta \ln p_i + \Delta \ln TFP_i = (\Delta \ln w^s)V_i^s + (\Delta \ln w^u)V_i^u \qquad (3)$$

Equation (2) says that changes in p_i or TFP_i can be accompanied by changes in w_s and w_u and still be consistent with zero profits. Note that the changes in w_s and w_u are weighted by factor cost shares which gives the effect on profitability.

We can use data on prices and outputs and inputs to construct Δp_i, ΔTFP_i, V_i^s, V_i^u. The terms Δw_s and Δw_u are unknown since they are the changes in economy-wide factor prices required to maintain zero profits. To find them, Haskel and Slaughter (2001), following Leamer (1998), estimate the following regressions:

$$\Delta \ln TFP_i = \beta_s V_i^s + \beta_u V_i^u + \gamma_k V_i^k + \varepsilon_i^1 \qquad (4)$$

$$\Delta \ln p_i = \gamma_s V_i^s + \gamma_u V_i^u + \gamma_k V_i^k + \varepsilon_i^1 \qquad (5)$$

where V^k, V^s and V^u are the cost shares of capital, skilled and unskilled labour in total output respectively. And ε^1 and ε^2 are errors arising from, for instance, measurement

[113] That is, if there is stronger technological change in skill-intensive industries, this requires an increase in skilled wages to get back to zero profit conditions. The same holds for price changes, a price increase in unskilled-intensive industries leads to a shift in production towards these industries and a necessary increase in the wages of unskilled workers to restore zero-profits in these industries.

error and the failure of zero profits to hold exactly. The results indicate whether TFP changes have been biased towards skilled or unskilled workers (4). It does the same for price changes (5). Both prices and technology are assumed to be exogenous.

3.4 Levels of Data Aggregation

A further question is the level of aggregation of the data to be used for the analysis. In the discussion above we have loosely referred to sectors without specifying what 'sectors' referred to. Studies that have used this methodology including Leamer (1998); Haskel and Slaughter (2001); Gregory and Zissimos (1999) have differed in that respect. While these studies have all used industry-level data, their applications have used very different levels of industry disaggregation. This ranged from 444 industries (Leamer, 1998) to 67 (Haskel and Slaughter, 2001). The choice was most likely driven by limitations to data availability. Specifically, price deflators are usually available only at more aggregated industry levels. What level of disaggregation would be most appropriate? Is this in any sense important? This theoretical framework is based on traditional trade theory which analyses industry sectors rather than firms. But what is meant by 'industry' and what is it the model wants to capture? The model is about heterogeneity across sectors in terms of different factor intensities $(V_i^s \neq V_j^s)$.

The expectation is that each industry sectors groups firms with comparable technology and skill-intensity. If too broadly defined industries are chosen, it may be that each industry includes firms with diverse production technologies and, hence, different factor intensities. In that case, results may wrongly label within-industry skill biases and specific compositional effects as sector bias. In order to find a suitable equivalent empirical studies have used firm information aggregated within industry classifications. While one may argue that firms that produce the same type of product have fairly similar products, it is not necessarily the case. For instance, larger firms within the industry may have a different more capital-intensive production technology than smaller firms because of scale economies. Indeed, we find that this is the case for our sample of firms. Less than 25% of the variance in the cost share of skilled labour can be explained by 4-digit ISIC Rev. 2 industry group. The number is below 10% for unskilled labour cost share. The number is significantly lower when we take it down to the 3-digit ISIC Rev. 2 industry level.

We, therefore, choose to do the analysis at the level of the firm in addition to using industry categories (ISIC Rev. 2). At the three-digit level, we have 29 different industries. By contrast at the four-digit level, there are 80 different industries in the sample. Further, the most disaggregated level of analysis we will use are firms themselves.

4. Data

The main database we will use is the Chilean manufacturing firm Census data (ENIA) provided by the Chilean National Institute of Statistics (INE). The unbalanced panel covers manufacturing firms with at least 10 employees. More detail on the main dataset in general is provided in Chapters 2 and 3. The information we use in this analysis is data on firms' value-added, the number of skilled and unskilled workers they employ as well as their wage bills and capital inputs. We classify workers into two groups based on occupation: Managers, qualified production workers and administrative staff are classified as skilled workers while unqualified production and non-production workers as well as support staff form part of the unskilled labour group. While the classification is not directly related to skills we feel confident that this is a relevant split also since on average individuals in the first set of occupations are more skilled than those in the second (Machin, 1996).[114] The capital stock is obtained using the perpetual inventory method as explained in the data appendix.

We use this information to compute cost shares as wage payments to skilled labour and unskilled workers over value-added. Note that since we do not have information on payments to capital, we follow Haskel and Slaughter (2001) and compute the payment to capital as equal to value added minus wage payments. Since we analyse the impact over a longer time period, we take the average of cost shares between 1996 and 2003 for our regressions.

For the computation of both price changes and TFP growth, we make use of a complementary dataset that gives detailed information on firms' products. We use information on the value and quantity of product sales to obtain firm-specific price indices. Following Eslava et al. (2004), we construct firm-level prices using Tornquist indices. Tornquist indices for plant *j* at time *t* selling products *i* are the weighted average of the growth in prices for all products:

$$\Delta P_{jt} = \sum_{i=1}^{I} \bar{s}_{ijt} \Delta \ln(P_{ijt}), \tag{5}$$

where

$$\Delta \ln(P_{ijt}) = \ln P_{ijt} - \ln P_{ijt-1}$$

and

$$\bar{s}_{ijt} = \frac{s_{ijt} - s_{ijt-1}}{2}$$

where P_{ijt} are prices charged for product *i* of plant *j* at time *t* while s_{ijt} and s_{ijt-1} are shares of product *i* in plant *j*'s total production for years *t* and *t-1*. The indices for the levels of output (or material) prices for each plant *j* are constructed using the weighted average of

[114] The same was used by Haskel and Slaughter, (2001) among many others.

the growth of prices fixing 1999 as the base year. Then the price index at time *t* for plant *j* is:

$$\ln P_{jt} = \ln P_{ijt-1} + \Delta P_{ijt} \qquad (6)$$

Note that the use firm-level price data significantly reduces sample size. A first reason is that certain price data were unavailable or have been removed due to potential outlier criterion. Second, since we look at changes over the time span 1996 – 2003 we only keep firms in the sample over the entire period. While this does not remove all concern, we can, however, demonstrate that our sample still captures changes in inequality well. It is comparable to the several statistics on relative wages for the complete sample of firms (Appendix Table 1). Finally, we compute the growth rate of prices between 1996 and 2003. Note that these price deflators were also used to correctly deflate firm value added in the computation of total factor productivity (TFP). We use the index method as specified in the Appendix. We compute TFP growth between 1996 and 2003.

5. Results

5.1 Main Results

Columns (1) and (2) of Table 1 show regression results of equations (4) and (5) that were estimated at the level of the firm. We obtain the "mandated" wage change by subtracting the estimated coefficient on the unskilled labour share from that of skilled labour. Our initial finding is that price changes mandated positive wage increases for skilled and unskilled workers but no change to existing wage inequality. For the regressions of price changes reported in column (2), coefficients for skilled and unskilled workers are not significantly different from one another. By contrast, as can be seen from column (1) technological change has been disproportionately to the benefit of firms that employ a higher share of unskilled workers. It appears as the main factor "mandating" a decrease in wage inequality for the period 1997 – 2003.

Table 2 compares the performance of our framework. It reports expected wage changes due to changes in prices and TFP along with actual wage changes. Predicted skilled wages obtain adding predicted changes due to changes in prices and TFP. If we take, for instance, results reported in columns 1 and 2 of Table 1, than the predicted change in skilled wages is of 16% due to prices and 9% due to TFP. The predicted wage change is, therefore, of 25%. We find that the actual change was in fact of 34%. It does, however, as all other estimates fall within the 95th confidence interval. Our evidence seems to underestimate positive impacts on skilled labour and overestimate those for unskilled labour. As a consequence, ours suggests a higher than actual decrease in wage inequality. The tendency is, however, correct and, if sampling error is taken into account, is supportive of the good performance of our framework.

Existing studies focused on explaining increased wage inequality in the United Kingdom and the United States. Haskel and Slaughter (2001) document significant price effects affecting the rise in inequality in the United Kingdom in the 1980s. TFP contributed to a significant rise in the 1970s. Feenstra and Hanson (1999) use a variant of the regression framework where foreign outsourcing and high-tech expenditure are used to indicate price and technology effects. They find significant impacts of both on wage inequality. Our results are quite different from these since they suggest an opposite tendency at least for technological change. However, it is important to bear in mind that we are considering both a different period and more importantly different economic context – the case of emerging economy Chile.

5.2 Robustness

As further robustness but, also, to see how results compare if we obtain them at the level of industries, we compute the same results aggregating our data to the 4-digit and 3-digit ISIC Rev. 2 industry classification levels. Results are reported in Tables 3 and 4. Three different results are obtained through different forms of aggregating the data. Columns (1) and (2) report data that are obtained taking a simple mean of firm-level information at the industry level. Columns (3) and (4) weight information by firm employment shares within the industry. Columns (5) and (6) show the same for firm shares in industry sales. Results remain qualitatively the same and support our main findings as to the positive impact of technological change, if measured by TFP, on relative wages. This is good news for industry-level studies since, judging at least from this case, a similar study for Chile at this more aggregate level would have produced the same main conclusions. However, we also find that results differ in terms of their magnitude. Specifically, results are quite different depending on whether employment or sales shares are used to weight observations.

Finally, a downside to using OLS regressions is that results may be driven by outliers. There is no fully established procedure to how to deal with this. Trying to use a more scientific approach, we do a couple of regression diagnostics of our main specification. First, we obtain studentized residuals to identify potential outliers. Second, we analyse leverage points (i.e. observations with extreme values of the independent variable). Third, we complement both tests with two very similar analyses of residuals and leverage jointly, Cook's D and DFITS. We use conventional cut-off points to exclude observations based on these criteria[115] and do the same regressions as in Table 1 for the resulting reduced sample. Whilst magnitudes vary somewhat, the direction of change is always similar. All in all we consistently find that productivity growth depresses wage inequality while trade-induced price changes have the opposite effect.

5.3 How Are Findings Related to Skill-biased Technological Change?

Our results show that technological change had a positive impact on wage inequality benefitting the relative wage remuneration of unskilled workers. This does not, however, say anything about the nature of technological change. That is, it does not tell us whether new technologies have been relatively more complimentary with skilled or unskilled workers so as to affect their relative contributions. What it suggests is that technological change was more important in unskilled-intensive sectors/firms and, therefore, generated greater profits in those sectors/firms. This shifted profit opportunities to the unskilled-intensive sector/firms generating a relative increase in the demand for unskilled workers up to the point where profits are down to zero again. The aspect that matters for overall effects is the relative effect of trade and productivity across firms/sectors rather than the specific nature of technological change.

6. Conclusion

There has been a decrease in wage inequality in the Chilean manufacturing sector from 1996 – 2003. We analyse the role trade and technological change played based on an empirical estimation that follows from a multi-sector model by Leamer (1998). The key intuition of the model is that with labour mobility across sectors and

[115] As for studentized residuals, we remove all observations with a value above and below 2.5. We remove all observations with a leverage value above (2k+2)/n, Cook's D above 4/n and DFITS above 2*sqrt(k/n) where k is the number of predictors and n the number of observations. The following website gives further detail on these tests: http://www.ats.ucla.edu/stat/stata/webbooks/reg/chapter2/statareg2.htm

differences in factor intensities across sectors, it is the sector-bias of technological change and trade that will affect relative wages rather than the characteristics of technological change. Our findings suggest that the decrease in wage inequality is due to technological change that affected low-skill-intensive sectors. Trade, by contrast, did not play a role in the decrease in relative wages as price effects were broadly similar across sectors with different skill intensities.

It is important to highlight several caveats to our findings that are worth emphasising. Most importantly, the evidence provided here relies on a stylised empirical model that relies on several assumptions that most likely do not hold. The most important case is the assumption of perfect competition in industries. This is not the case for Chile. But if assumptions do not hold, it is unclear whether one should expect the outcomes predicted by theory. Leaving questions of the underlying model aside, the empirical analysis relies on the unproven hypothesis that price changes are due to the impacts of trade and changes in total factor productivity due to those of technological change. There are, however, many other factors such as demand shocks that could affect prices beyond the impacts of trade. Similarly, as discussed in Chapter 2 TFP might capture other aspects than technological change. Further research would be necessary to clearly establish whether the effects of these factors can indeed mainly be attributed to the impacts of trade and technological change. Moreover, it would be useful to have a study on the impacts of the rise in minimum wages from 1998 to 2001 to dismiss concerns that they might have had an impact on the trends described here. Finally, there was an increase in employment of about 7% over the 1996 – 2003 period that might have had effects depending on its skills composition we are not capturing in this study.

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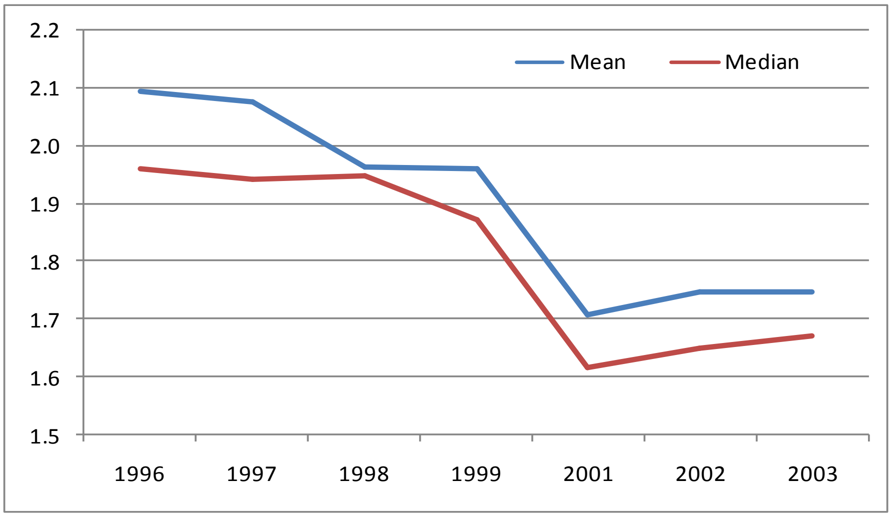
Chapter 5:   Figures and Tables

Figure 1: Mean and Median Wage Inequality in Chilean Manufacturing from 1996 to 2003



Notes: Wage inequality is defined as the ratio of average skilled wages over average unskilled wages. Information on wages is missing in 2000 and is, therefore, not included here. Mean and median values are based on the estimating sample. As shown in Appendix Table 1 the results are similar to those for the complete manufacturing Census dataset.

Table 1:   Mandated Wage Equations at the Firm-Level for 1996 - 2003

	Estimation Method: OLS	
	Dependent Variables:	
	Δ ln *TFP*	Δ ln Price
	(1)	(2)
Skilled share	0.0882	0.163***
	(0.074)	(0.011)
Unskilled share	0.645***	0.139***
	(0.220)	(0.021)
Capital share	-0.224***	0.157***
	(0.068)	(0.011)
Mandated % rise in wage inequality	-0.557	0.024
P-value	0.04	0.34
Employment Weight	No	No
Observations	1701	1701
R-squared	0.06	0.14

Notes: Columns (1) and (2) report results of estimating equations (4) and (5) for the entire sample of firms with valid information on prices and productivity growth. We report robust standard errors in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% confidence levels, respectively.

Table 2: Net Mandated and Actual Wage Changes

	Based on Columns (1) and (2)		
Δw s mandated	*0.104*	0.251	*0.398*
Δw s actual		0.341	
Δw u mandated	*0.351*	0.784	*1.217*
Δw u actual		0.514	
Δ(w s - wu) mandated	*-0.990*	-0.533	*-0.076*
Δ(w s - wu) actual		-0.173	

Notes: We obtain "mandated" wages by adding estimates reported in columns (1) and (2) of Table 1 for each type of labor where s refers to skilled and u to unskilled workers. The predicted change in wage inequality is obtained by subtracting the predicted unskilled wage changes from those for skilled wages. We also report actual wage changes computed based on the estimating sample. 95 percent confidence intervals are provided in italics.

Table 3: Mandated Wage Equations at the 4-digit Industry Level for 1996 – 2003

	Estimation Method: OLS					
	Dependent Variables:					
	Simple Mean		*Employment Weighted Mean*		*Output Weighted Mean*	
	Δ ln *TFP*	Δ ln Price	Δ ln *TFP*	Δ ln Price	Δ ln *TFP*	Δ ln Price
	(1)	(2)	(3)	(4)	(5)	(6)
Skilled share	-0.0447	0.171***	0.0491	0.161***	0.0927	0.167***
	(0.190)	(0.052)	(0.170)	(0.055)	(0.180)	(0.047)
Unskilled share	1.122	-0.0178	1.125	-0.00197	0.508	-0.0967
	(0.970)	(0.220)	(0.950)	(0.300)	(1.630)	(0.320)
Capital share	-0.360*	0.180***	-0.264	0.168***	-0.201	0.177***
	(0.190)	(0.056)	(0.170)	(0.059)	(0.180)	(0.052)
Mandated % rise in wage inequality	-1.167	0.189	-1.0759	0.163	-0.4153	0.2637
P-value	0.30	0.47	0.33	0.64	0.82	0.46
Observations	80	80	80	80	80	80
R-squared	0.14	0.34	0.30	0.25	0.07	0.24

Notes: The table shows results of estimating equations (4) and (5) by 4-digit ISIC Rev. 2 industry. Columns (1) and (2) report results for industry-level observations that were obtained by taking simple averages. Columns (3), (4), (5) and (6) report results for averages weighted by firm employment (Columns 3 and 4) and output size (Columns 5 and 6) respectively.

Table 4: Mandated Wage Equations at the 3-digit Industry level for 1996 – 2003

	Estimation Method: OLS					
	Dependent Variables:					
	Simple Mean		*Employment Weighted Mean*		*Output Weighted Mean*	
	Δ ln *TFP*	Δ ln Price	Δ ln *TFP*	Δ ln Price	Δ ln *TFP*	Δ ln Price
	(1)	(2)	(3)	(4)	(5)	(6)
Skilled share	-0.038	0.088	0.068	0.124	-0.011	0.186**
	-0.18	-0.067	-0.2	-0.1	-0.2	-0.081
Unskilled share	1.726*	-0.036	1.765	0.006	2.248	-0.825
	-0.85	-0.29	-1.08	-0.64	-1.68	-0.79
Capital share	-0.454*	0.217**	-0.228	0.171	-0.238	0.247**
	-0.23	-0.087	-0.23	-0.11	-0.23	-0.095
Mandated % rise in wage inequality	-1.764	0.124	-1.697	0.118	-2.259	1.011
P-value	0.09	0.73	0.19	0.87	0.23	0.25
Observations	29	29	29	29	29	29
R-squared	0.42	0.66	0.45	0.29	0.19	0.24

Notes: The table shows results of estimating equations (4) and (5) by 3-digit ISIC Rev. 2 industry. Columns (1) and (2) report results for industry-level observations that were obtained by taking simple averages. Columns (3), (4), (5) and (6) report results for averages weighted by firm employment (Columns 3 and 4) and output size (Columns 5 and 6) respectively.

Table 5: Robustness: Removing Influential Outliers

	Estimation Method: OLS	
	Dependent Variables:	
	Δ ln *TFP*	Δ ln Price
	(1)	(2)
Skilled share	0.821***	0.263***
	(0.120)	(0.050)
Unskilled share	1.208***	0.161***
	(0.120)	(0.048)
Capital share	-0.405***	0.180***
	(0.040)	(0.017)
Mandated % rise in wage inequality	-0.387	0.102
P-value	0.04	0.19
Employment Weight	No	No
Observations	1616	1616
R-squared	0.11	0.24

Notes: Columns (1) and (2) report results of estimating equations (4) and (5) for a firm sample where potentially significant outliers and leverage points have been removed. These have been identified using four regression diagnostics tests (Cook's D, DFITS, leverage and studentized residuals). We report robust standard errors. *, **, and *** indicate significance at 10%, 5% and 1% confidence levels, respectively.

Data Appendix

As **basic output** measure we use firms' value-added output deflated using firm-specific price indices obtained as specified in Section 4. The **materials** measure includes deflated expenditure on intermediate inputs, electricity and water. The materials price deflator is based on a weighted average of the aforementioned 3-digit output price deflators where the weights are given by the share that each 3-digit industry's output represents in total manufacturing intermediates used by all 3-digit industries based on an input-output table. For years 1996-2002 [2003-2004], the weights are based on the 1986 [1996] Chilean input-output table.

Capital is computed using the perpetual inventory method (PIM). The ENIA survey provides information on four types of capital: buildings, machinery and equipment, transport equipment, and land. For each type of capital we compute net investment flows as the sum of purchases of new capital, purchases of used capital and improvements to capital minus the sales of capital and deflate these by an investment price deflator constructed as the ratio of current gross capital formation to constant gross capital formation (in local currency units) from the World Development Indicators with base year 2002. For each type of capital, the PIM formula $K_{it+1} = (1 - \delta) K_{it} + I_{it}$ is applied, where I_{it} are real net investment flows and δ is a depreciation rate. Since detailed studies of depreciation rates in Chile are unavailable, we use the following rates proposed by Pombo (1999) who studied the same type of capital goods in Colombia: 3% for buildings, 7% for machinery and equipment, and 11.9% for transport equipment. Land is assumed not to depreciate. We also experimented with alternative rates of depreciation but did not find this to make a substantial difference to the final capital stock values nor to our main results. The initial value of the capital stock needed to apply the PIM formula is given by the book value of each of the four types of capital in the first year of plant presence in the sample. Whenever the book value is available only in a latter year, we back out that value until the plant's first year in the sample taking into account the investment price deflator and the corresponding depreciation rate.

Total Factor Productivity growth is the residual growth of output not explained by production input growth. In this framework, these inputs are the log of skilled and unskilled labour, capital and materials computed as described above and in Section 2.

Measuring the returns to capital is a well-known problem in the empirical literature (Hulten, 2000). In order to avoid this problem, we assume that product functions exhibit constant returns to scale and compute capital as the residual of the other three input shares. We compute the following to obtain TFP growth:

$$\Delta \ln TFP_{it} = \Delta VA_{it} - s_{Sit}\Delta \ln Ls_{it} - s_{Uit}\Delta \ln Lu_{it} - s_{Kit}\Delta \ln K_{it} \qquad \text{(A1)}$$

where

$$s_{Sit} = \frac{w_{Sit}Ls_{it}}{p_{it}VA_{it}}, \; s_{Uit} = \frac{w_{Uit}Lu_{it}}{p_{it}VA_{it}} \qquad \text{and} \qquad s_{Kit} = 1 - s_{Sit} - s_{Uit}$$

where *VA*, *L*, *K* and *M* are value-added output and labour, capital and materials inputs of firm *i* at time *t*. Further, *s* denotes the shares of each in total revenue, where *p* is the general price level whereas w_S and w_U are wages of skilled and unskilled labour of firm *i* at time *t*. We compute the share of each type of labour as the share of its total wage bill over value-added. Using value-added instead of sales output means we already exclude from the output measure materials and other intermediate inputs.

The main advantage of this approach, proposed by Solow, is that it is a straightforward non-parametric procedure to estimate TFP growth. All that is necessary for computation are price and output data, the exact production function does not have to be estimated. This comes at a cost, namely the assumption of marginal cost pricing. However, this is well in line with the competitive market hypothesis the 'mandated wage equation' approach relies on.

Appendix. Table

Table 1: Relative Wage Statistics for the Complete Firm Census and the Estimating Sample

Panel A: Mean values

	Skilled wages in total		*Skilled employment in total*		*Skill premium*		*Skilled wages*		*Unskilled wages*		*Wage inequality*	
Year	Census	Sample	Census	Sample	Census	Sample	Census	Sample	Census	Sample	Census	Sample
1996	0.38	0.39	0.37	0.33	1.67	1.63	4,106	4,281	2,014	2,043	2.04	2.10
1997	0.38	0.42	0.43	0.36	1.64	1.63	4,256	4,622	2,177	2,225	1.96	2.08
1998	0.39	0.42	0.42	0.35	1.64	1.58	4,607	4,974	2,325	2,534	1.98	1.96
1999	0.40	0.44	0.44	0.39	1.60	1.54	4,710	5,131	2,468	2,617	1.91	1.96
2001	0.42	0.46	0.50	0.45	1.49	1.40	5,204	5,628	3,021	3,294	1.72	1.71
2002	0.42	0.47	0.51	0.45	1.51	1.43	5,549	5,962	3,116	3,410	1.78	1.75
2003	0.43	0.47	0.50	0.45	1.52	1.44	6,024	6,522	3,368	3,730	1.79	1.75

Panel B: Median values

	Skilled wage share		*Skilled employment share*		*Skill premium*		*Skilled wages*		*Unskilled wages*		*Wage inequality*	
Year	Census	Sample	Census	Sample	Census	Sample	Census	Sample	Census	Sample	Census	Sample
1996	0.33	0.34	0.21	0.21	1.44	1.41	3,206	3,404	1,717	1,737	1.87	1.96
1997	0.34	0.36	0.23	0.22	1.42	1.36	3,424	3,649	1,885	1,878	1.82	1.94
1998	0.34	0.36	0.23	0.22	1.43	1.37	3,766	3,993	2,037	2,050	1.85	1.95
1999	0.35	0.38	0.26	0.24	1.40	1.32	3,766	4,062	2,135	2,170	1.76	1.87
2001	0.37	0.40	0.29	0.27	1.33	1.25	4,065	4,474	2,605	2,770	1.56	1.62
2002	0.38	0.41	0.29	0.27	1.33	1.25	4,241	4,666	2,676	2,830	1.58	1.65
2003	0.40	0.42	0.30	0.27	1.35	1.26	4,656	5,015	2,870	3,002	1.62	1.67

Notes: The wage share of skilled workers is computed as the wage share of skilled workers over the joint wages of skilled and unskilled workers. The employment share of skilled workers is obtained as the ratio of the number of skilled workers over overall employment. The skill premium is computed as the ratio of average skilled wages over average wages. Skilled and unskilled wages are reported in thousands of Chilean pesos. Finally, we compute wage inequality as the ratio of skilled wages over unskilled wages. The statistics for the Census dataset include all observations except for the top and bottom 1% of average skilled and unskilled wages to remove possible outliers. Statistics for the Estimating sample use information for all firms entering our main regressions in Table 1.