Trade liberalization and labor market evolution: Evidence from Chilean plant level data

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October 2003

Abstract

We document the evolution and composition of labor in Chilean manufacturing over the period 1979-1995. This period is notable in that it follows a substantial trade liberalization of the Chilean economy. The average share of skilled labor in total plant employment increases by eight percent, whereas the average wagebill share of skilled workers rises by sixteen percent during this period. Consistent with skill biased technological change (SBTC), most of the shift in labor composition is accounted for by within rather than between industry variation. By sorting the data into export-oriented, import-competing and non-tradable categories, we examine the effect of trade liberalization on labor composition. The wage bill share of white collar workers in total employment is higher in the import-competing and non-tradable sectors relative to the export-oriented sector. The wage bill share grew most rapidly for the non-tradable sector. Using a cost minimization approach to analyze the plant-level determinants of the share of skilled workers in the wage bill, we find strong evidence that the wage-bill share for skilled workers is positively related to measures of technology adoption such as foreign direct technical assistance, providing further support for SBTC. We also find strong evidence of capital-skill complementarity for the import-competing sector of manufacturing. We find no evidence of capital-skill complementarity for the export-oriented sector.

1 Introduction

Many developing and developed economies consider structural reforms to trade and fiscal policy that are designed to lower taxes and tariffs and stimulate investment and production of the manufacturing sector. A good example of such a country is Chile which went through a series of structural reforms in the late 1970s and early 1980s. The labor and financial markets were deregulated and price controls eliminated. Two major tax reforms were put into operation in 1975 and 1984, and a social security reform was introduced in 1980. In addition, Chile was one of the first countries in Latin America to begin a gradual but deep trade liberalization process. In 1967 the average effective protection rate was over 100%. Between 1973 and 1979, Chile eliminated the quantitative restrictions and reduced the import tariff to a uniform level of 10%. Responding to a debt crisis in 1982, some reforms were delayed and others were partially reversed (the import tariffs were temporarily increased to 35% in 1984), but by 1992 all of them were successfully in place.

We expect that such dramatic changes in the free-trade environment will have first-order implications for labor markets in Chile. The standard Heckscher-Ohlin model predicts that a low labor-cost country like Chile trading with high labor-cost developed economies such as the United States will experience a fall in the capital-labor ratio and a reduction in demand for skilled workers relative to unskilled workers once trade barriers are reduced. More recent theories lead to the opposite conclusion however, if trade liberalization is associated with the adoption of new technologies and/or a shift towards importing high-technology capital goods that are complementary with skilled labor. In this case, trade liberalization may lead to rising capital-labor ratios and a shift towards skilled labor relative to unskilled labor. Trade liberalization may also imply increased wage inequality owing to such skill-biased technological change.

Existing research provides strong support for the notion that technological change is indeed skill-biased, and that such skill-bias is transmitted across countries following trade liberalizations. Empirical evidence for OECD countries suggests that unskilled workers have experienced a deterioration in their wages over the last two decades despite their increasing relative scarcity. Most industries in these countries have experienced an increasing participation of skilled workers in the labor force despite the fact that their relative wages have increased or remained stable compared to unskilled workers.

Studies investigating the evolution and behavior of the wage structure in developed countries have become important research topics in the last few years.[1] The empirical evidence is consistent with a considerable rise in wage inequality and demand for skilled workers in the United States and United Kingdom and only a moderate increase in countries like Japan, Sweden and Germany (Machin and Van Reenen, 1998).

For developed economies, this literature has advanced several hypotheses to explain the increased demand for skilled relative to unskilled workers, including skill-biased technological change and Stolper-Samuelson effects of exposure to trade. While, there is no consensus, researchers tend to agree that the main force behind the behavior of relative wages and relative demand for skilled versus unskilled workers in developed economies is the presence of pervasive skill-biased technological change (SBTC). The arguments in favor of this hypothesis can be summarized as: (1) the increase in skill intensity and wage premium have occurred within, rather than between industries; (2) these observed shifts tend to be concentrated in the same industries across countries; (3) capital-skill complementarity seems to be small (Berman and Machin, 2000); and (4) employment shifts to skill-intensive sectors appear to be too small to be consistent with the notion that international trade mechanisms are the prime determinants of the changing skill-mix.

For developing economies there are only a few studies analyzing changes in wage and labor structure. For the case of Mexico, the findings suggest that returns to higher education increased between the late 80's and mid 90's (Meza, 1999), and that the shifts in the relative demand for skilled workers have taken place mostly within industries. Craig and Epelbaum (1994) found evidence to support capital-skill complementarity in explaining the increase in the wage dispersion. Hanson and Harrison (1999) explained the increase in wage inequality in Mexican firms in the late 80's arguing that the reduction in trade protection that took place in 1985 affected more low-skilled industries, those receiving relatively high trade protection before the liberalization process. Similar results were found by Revenga (1997). Robbins (1994, 1995b) found evidence of higher wage inequality following trade liberalization in the case of Chile. For Colombia, the results were mixed. After experiencing a fall in wage disparity following the trade reform, the relative wage for skilled workers increased after 1987. For the Brazilian economy, male wage inequality remained basically unaltered between the 80's and 90's. There were two counteracting effects: (1) the compression effect –decline in returns to education with the rise in education levels– reduced the wage dispersion between groups; (2) the composition effect –rise in education inequality– increased the wage

[1] See Katz and Autor (1999) for a survey

dispersion.

Cross country analyses have found some evidence of skill biased technical transfer. Berman and Machin (2000) using data for middle income countries, found increasing demand for skilled workers, which concentrated in the same industries and highly correlated with indicators of OECD technical change. Robbins (1995a) found a high correlation between the increasing demand for skilled labor and imports of machinery and equipment, also known as the skill enhancing trade hypothesis.

In a closely related study, Pavnik (2002b) examines the evolution of the white-collar share for Chilean manufacturing plants over the period 1979-1986. Pavnik finds evidence in favor of skill-biased technological change, and capital-skill complementarity. Building on her approach, we extend the analysis over an additional nine years to cover the period 1979-1995. This extended data is much better suited to analyzing long-run trend issues such as the evolution of skill-bias in the Chilean labor market following such significant trade liberalization. Unlike Pavnik, we also dissagregate the data by trade orientation, classifying firms by whether they are in export-oriented, import-competing or non-tradable sectors.

Our paper begins with a descriptive exercise, characterizing the broad movements in factor intensity, labor composition and wage structure between skilled and unskilled workers over the period 1979-1995. Our findings imply that the wage bill share for white collar workers has risen in all three sectors of manufacturing. The non-tradable sector shows the largest increase. The effect of a sharp rise in the white collar share for the non-tradable sector is diminished somewhat in the aggregate, as manufacturing production activity shifted away from non-tradables towards exports over this period however.

Having completed this descriptive exercise, we then consider a more formal analysis of the relationship between trade-liberalization and labor market outcomes. We adopt a cost minimization approach based on a restricted variable translog cost function to provide direct estimates of the relative demand for skilled workers. The same methodology has been used to study the presence of SBTC in developed economies (Berman and Machin (2000)) and developing economies (Pavnik (2002b)).

According to our analysis, most of the change in the relative demand for skilled workers as well as the shifts in the share of skilled labor in the wage bill have been within rather than between industries. This finding provides preliminary support for the existence of SBTC. From our regression analysis we find evidence that the white-collar wage share is strongly associated with measures of technology adoption across all three sectors of manufacturing.

Controlling for unobserved heterogeneity weakens these results for the export-oriented and non-tradeable sector however. We also find strong evidence of capital-skill complementarity in the import-competing sector. In contrast, we find no evidence of capital-skill complementarity for export-oriented plants.

The paper is organized in the following way. Section 2 gives a brief description of the trade liberalization process in Chile. Section 3 provides descriptive statistics documenting the composition and evolution of manufacturing employment. Here we divide plants into industrial sectors based on their trade orientation. We also provide summary statistics regarding capital intensity and growth rates for value-added and factor inputs for each of these sectors. In Section 4, we provide a more formal analysis of the evolution of the skilled versus unskilled worker mix: we decompose shifts in the labor share for skilled workers into within and between industry variations and we use a cost minimization approach to study the relationship between labor composition, capital deepening and technology adoption. Section 5 concludes.

2 Background

During the 60's and early 70's, Chile, as well as much of Latin America, followed an import substitution policy, characterized by high and differentiated tariffs, quotas, market regulations and a system of multiple exchange rates. After the coup d'etat in 1973, the new government introduced a series of structural reforms in the late 1970's and early 1980's. Quantitative restrictions were eliminated between 1973 and 1975 and import tariffs reduced from 105% in 1973 to a uniform level of 10% by June of 1979. The trade liberalization process was also accompanied by reforms to the labor and capital markets. Banks and public companies were privatized and price controls eliminated. The capital market was deregulated, letting the market set the interest rate, and the government removed all quantitative restrictions on external borrowing.

These measures were combined with contractionary macroeconomic policies which, together with an international slowdown in copper prices and oil, pushed the economy into a recession that lasted until 1975. Once the economy started to recover between 1979-1981, the main objective of the government was to reduce inflation based on an exchange rate policy. By 1979, the annual inflation rate was close to 30% and in an effort to stop the vicious cycle of inflation and depreciation, the nominal exchange rate was pegged to 39 pesos per dollar. Between 1979 and 1982, the public sector accumulated a large debt, there were high world interest rates, a large trade deficit, a deterioration of the real exchange rate and terms of trade, which led to the abandonment of the peso peg in June of 1982. The Latin America debt crisis put the economy in a deep recession and as a response, trade restrictions were implemented and the average tariff rate rose to 20% in 1983 and 35% in 1984. Regardless of indexation, the real exchange rate depreciated by nearly 30% between 1982 and 1986. Chile restructured its external liabilities by giving commercial banks annual appointments to work out debts and setting up special arrangements for dollar debtors. This gave way to the return of the world capital market which had lost confidence in Latin American countries that had been unable to meet their debt service. The domesitic economy recovered and trade was again liberalized and by 1988 tariffs had been brought down to 15%.

In 1989 the new democratic government was elected. Despite some fears that market-oriented policies implemented between the 1970's and 1980's would be reversed, the new government not only maintained the main aspects of the market reforms, but also furthered trade liberalization by installing a uniform 11% tariff by 1991. Begining in 1992, the strategy was one of bilateral liberalization, oriented to promote manufacturing exports. During the early 90's, the real exchange rate nor the terms of trade played an important role in the liberalization process. The real exchange rate declined steadily and the terms of trade remained relatively constant.

3 Data Overview

Given the macroeconomic volatility and structural changes that have occurred over this period, we believe that having a large panel data from 1979 to 1995 is particularly important for understanding both wages and employment dynamics at the plant level. Previous research on employment and productivity dynamics using information for Chilean manufacturing plants has only considered information between 1979 and 1986.[2] The topics analyzed have been related to the effects of trade liberalization in total factor productivity, the role of plant exit and entry on manufacturing productivity growth, the effect of trade in total employment movements; and the role of the adoption of foreign technology in explaining the

[2]Which coincides with years for which Chilean plant-level data were obtained and made available by the World Bank.

evolution of the relative demand for skilled workers.[3]

Our current data set is obtained from World Bank and *Instituto Nacional de Estadisticas de Chile* (INE) sources and is comprised of plant-level data for Chilean manufacturing plants. In the cleaned sample, we have a total of 6,665 plants in the manufacturing sector with 10 or more employees. The dataset contains annual information for the period 1979-1995, and includes a large set of variables about production, employment, investment, capital stocks, intermediate inputs and plant entry and exit. All variables considered are in terms of 1980 prices. The data was collected by INE. After the elimination of extreme outliers, this panel data set contains 63,686 observations across plants and years.

We constructed appropriately defined capital indices using the perpetual inventory method, aggregated material inputs using correct industry-level deflators, and put all variables on a comparably deflated basis.

Employment is measured as the number of workers hired per year and is decomposed by skill-type: white-collar and blue-collar. Given that we want to study the relationship between employment composition according to skill level, trade orientation and technology adoption, we needed proxies for the technology measure. The proxies for use of technology provided by the data were: imported materials and expenditures on foreign technical assistance. Unfortunately, we do not have information on foreign direct investment nor on expenditures on research and development, which are the variables commonly chosen as ideal proxies for technology measures.

3.1 Sectoral classification

To classify plants based on their trade orientation, we rely on information on imports and exports from the Statistics Canada CD-ROM (Trade Analyzer). The level of disaggregation in the information obtained from Statistics Canada allowed us to improve on previous definitions provided by Liu (1991), which were computed only at the 3-digit level; and also to update the information between 1987 and 1995. In particular, plants that belong to a 4-digit industry exporting more than 15% of the industry's output were characterized as export-oriented plants. Likewise, plants in an industry where the ratio of total imports

[3] Pavcnik (2002a) using information for Chilean industrial plants, concluded that productivity increased in a range of 3-10% in the import-competing sector due to trade liberalization; yet findings for the export-oriented sector were not conclusive. Liu and Tybout (1996) and Tybout (1996) used the 1979-1986 sample to study productivity dynamics at the plant-level while Levinsohn (1996) studied job creation and destruction using this data set.

to total domestic output is higher than 15% are characterized as import-competing. The remaining plants were classified as belonging to the non-tradable sector.

Table 1 summarizes the sectoral classification across three-digit industries while tables 2 , 3 and 4 document the evolution of plant size and the share of manufacturing value-added and employment accounted for by each sector. Unsurprisingly, Table 1 indicates that export-oriented industries are concentrated in wood, paper and mining, while import-competing industries are much more heterogenous.

Table 1: Industrial composition of trade orientation sectors

Code	Description	Export-oriented	Import-competing	Non-tradable
311	Food	15	16	69
313	Beverage			100
314	Tobacco			100
321	Textiles		100	
322	Apparel		100	
323	Leather products			100
324	Footwear		100	
331	Wood products	100		
332	Furniture			100
341	Paper	100		
342	Printing			100
351	Industrial chemicals		100	
352	Other chemicals			100
353	Petroleum refining			100
354	Misc. petroleum prod.			100
355	Rubber			100
356	Plastics		100	
361	Ceramics		100	
362	Glass		100	
369	Non-metallic minerals			100
371	Iron and steel			100
372	Non-ferreus metals	100		
381	Metal products		100	
382	Non-electric machinery		100	
383	Electric machinery		100	
384	Transport equipment		100	
385	Professional equipment		100	
390	Miscellaneous		100	

Table 2 provides sample means for the number of employees per plant, for both the full-sample and the sub-samples where industries are split based on trade orientation. On average, Chilean plants are much smaller than their developed country (U.S.) counterparts. Plants in export-oriented industries are larger than other plants, and this size discrepancy increases over the sample period. In 1979, export-oriented plants are 26% larger than the average plant, while in 1995, this size discrepancy increases to 46%. At the beginining of the sample, import-competing plants are also significantly larger than plants in the non-tradable sector. This difference erodes over time however. Using labor as a measure of size, the overall finding from Table 2 is that plant size in the export-oriented sector appears to have expanded much more than plant size in other sectors.[4]

Table 2: Plant total employment means

Year	Export-oriented	Import-competing	Non-tradable	Full sample
1979	58	52	34	46
1980	64	51	37	47
1981	69	55	37	49
1982	60	50	35	45
1983	65	49	36	45
1984	70	53	37	49
1985	73	57	39	52
1986	90	67	45	60
1987	91	64	45	60
1988	96	69	46	64
1989	101	72	48	67
1990	100	73	50	68
1991	98	69	49	66
1992	93	69	49	65
1993	93	69	50	65
1994	94	68	50	65
1995	95	67	50	65

The increase in plant size for export-oriented firms occurs in conjunction with an overall expansion of the export-oriented sector relative to the other two sectors. Table 3 documents the share of value-added accounted for by plants in each sector. According to our sample, the export sector's share of value-added has risen 14% to 19% over the sample period while

[4]This does not necessarily imply that total employment has increased more rapidly for export-oriented sectors relative to import-competing however.

both the import-competing and non-tradables share have fallen somewhat during this time. The import-competing sector accounts for the largest component of manufacturing economic activity however – on the order of 50 percent.

Table 3: Value added share

	Export-oriented	Import-competing	Non-tradable
1979	0.141	0.513	0.346
1980	0.127	0.505	0.368
1981	0.149	0.495	0.357
1982	0.177	0.470	0.353
1983	0.192	0.442	0.366
1984	0.194	0.469	0.337
1985	0.207	0.471	0.322
1986	0.177	0.486	0.336
1987	0.184	0.499	0.317
1988	0.220	0.498	0.281
1989	0.211	0.489	0.300
1990	0.195	0.503	0.302
1991	0.199	0.512	0.289
1992	0.197	0.504	0.299
1993	0.193	0.517	0.290
1994	0.189	0.530	0.281
1995	0.190	0.531	0.278

Table 4: Total employment share

	Export-oriented	Import-competing	Non-tradable
1979	0.154	0.558	0.288
1980	0.145	0.540	0.315
1981	0.163	0.529	0.308
1982	0.156	0.515	0.329
1983	0.177	0.491	0.332
1984	0.190	0.507	0.302
1985	0.200	0.504	0.295
1986	0.164	0.526	0.310
1987	0.192	0.527	0.280
1988	0.199	0.536	0.264
1989	0.202	0.530	0.268
1990	0.200	0.524	0.275
1991	0.208	0.515	0.277
1992	0.202	0.520	0.277
1993	0.205	0.518	0.276
1994	0.209	0.518	0.274
1995	0.205	0.529	0.266

Table 4 documents the share of manufacturing employment accounted for by each sector. For the export-oriented sector, the employment share shows a similar increase as the value-added share. In contrast to the value-added share, the employment share for the import-competing sector fell somewhat over this time period however. The employment share for the non-tradable sector also fell, though the drop is muted relative to the drop in the value-added share of this sector.

3.2 Sectoral dynamics and factor intensity

Figure 1 documents the growth rates of value added for each sector. These growth rates display similar cyclical patterns over time, with the exception that the export-oriented sector expanded rapidly during the early 1980's when the rest of the manufacturing sector was mired in recession. Over the full sample period, the import-competing sector has grown faster – 6.2% on an annual basis – than the export-oriented and non-tradable sectors, which grew at 5.6% and 5.1% respectively. The overall growth rate for our manufacturing sample was 5.8% over this period.[5]

[5]Because our data is a sample rather than the full universe of manufacturing plants, we measure growth rates for plants that are in the sample over consecutive periods. Let n_{t-1} denote the set of firms with

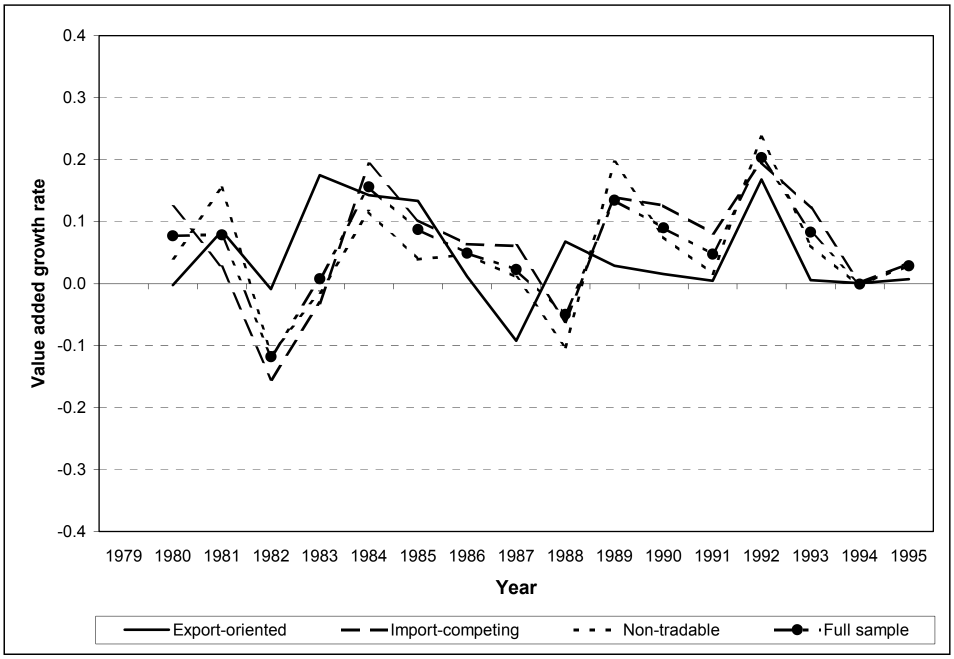

Figure 1: Value added growth rates by sector.

Figures 2 and 3 document the evolution of labor productivity (output per employee) and capital productivity (output per unit of capital) for each sector over the 1979-1995 period while Table 5 provides average annual growth rates over this period.[6] Labor productivity grew most rapidly in the export-oriented sector – at an average annual rate of 3.8%, and least rapidly in the non-tradable sector (2.2% on average). Capital productivity grew rapidly for the export and non-tradeables sectors – at an average annual rate of 3.3% and 4.2%. Measured by output per unit of capital, the import competing sector effectively became substantially more capital intensive than the other two sectors over this time period. Measuring total factor productivity as a weighted average of labor and capital productivity, these numbers imply substantial gains in the productivity for the export-oriented sector

observations available for both t and $t-1$. The growth rate of value added is then computed as

$$g_t^{VA} = \log\left(\sum_{i \; in \; n_{t-1}} VA_{it}\right) - \log\left(\sum_{i \; in \; n_{t-1}} VA_{it-1}\right).$$

[6] Because the capital stock data are not available for plants that enter the sample after 1981, there is likely some bias in the labor-intensity, capital-output ratios and TFP numbers documented in Figures 2 and Table 5. Thus, we treat these numbers as informative rather than definitive. In contrast, the labor productivity numbers are not subject to such potential biases.

relative to the import-competing and non-tradable sectors. The finding that the import-competing sector has become more capital intensive relative to the other two sectors over time is consistent with the notion that trade liberalization allowed import-competing firms to increase their capital intensity through the adoption of imported machinery.

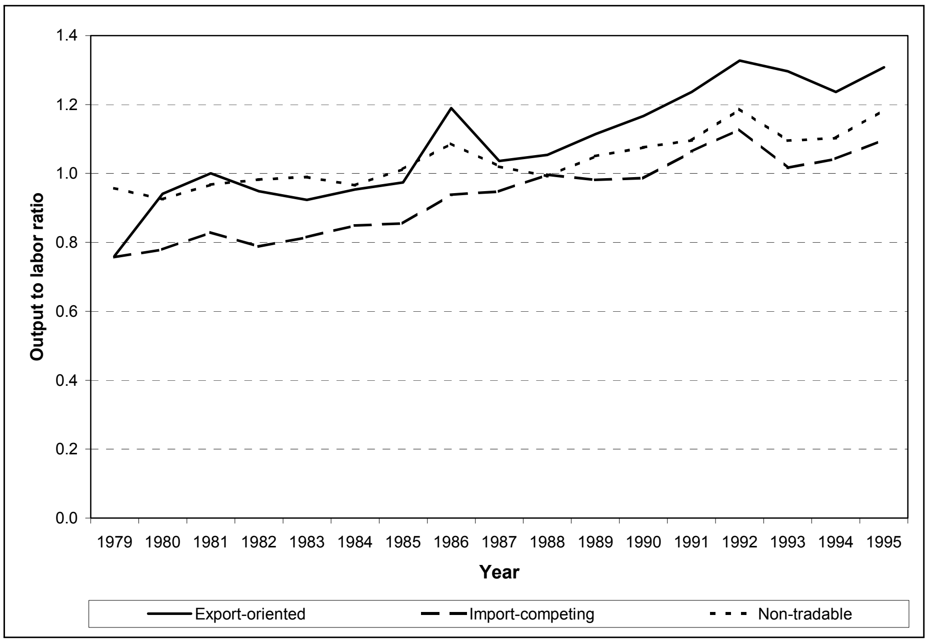

Figure 2: Labor productivity

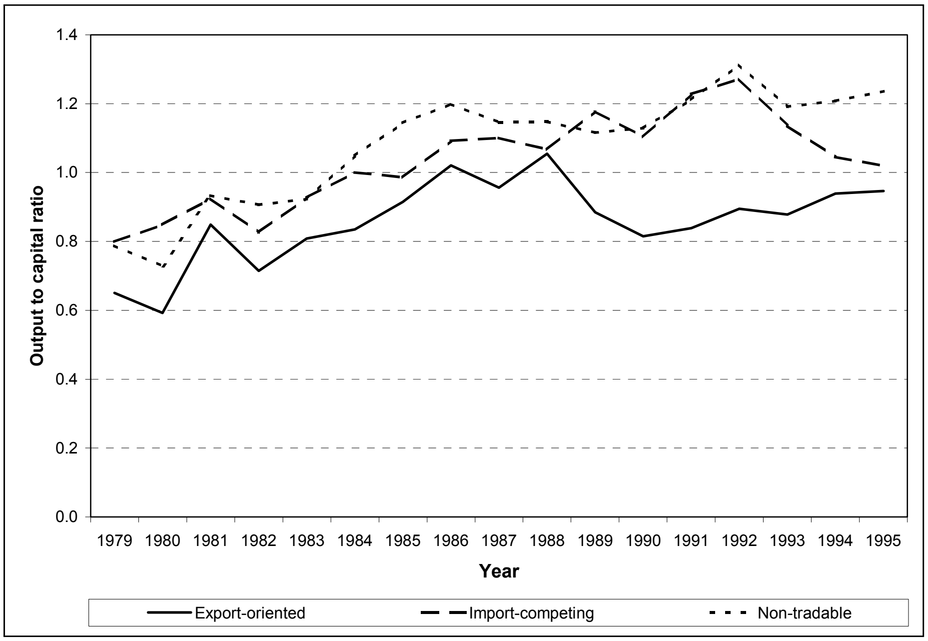

Figure 3: Capital productivity

Table 5: Average annual growth rate 1979-1995

	Export-oriented	Import-competing	Non-tradable	Full sample
Output to capital	3.3	2.6	4.2	3.3
Output to labor	3.8	3.3	2.2	2.9
Labor to capital	-0.5	-0.7	2.0	0.4
TFP	3.7	3.0	2.8	3.0

3.3 Labor composition by sector

We now document trends in labor composition between skilled and unskilled workers. Table 6 summarizes the evolution of the white-collar share of total employment. Here we report the ratio of white-collar employees in each sector divided by the total number of employees in each sector. The share of white-collar workers in total employment is higher in the import-competing sector relative to the export-oriented sector. There is no significant difference in terms of skill composition between the import-oriented and non-tradable sectors. The overall share of skilled workers in total employment displays moderate increases over time, showing a rise of 8% for the full sample in the period 1979-1995. Notice that for 1982, year in which the real GDP decreased more than 15% as a consequence of the debt crisis, the white-collar to total employment ratio increased by 19%, 11% and 9% relative to the average of the previous three years for plants in the export-oriented, import-competing and non-tradable. After 1983 these shares scaled back to previous values. This is consistent with previous evidence given by Levinsohn (1996,1998). He compared employment growth rates for different skill types and found that job growth rates for unskilled workers decreased more quickly as the economy enters a recession period and recovered faster compared to skilled workers job growth. In contrast to the import-competing and non-tradable sectors, the white-collar share of employment in the export-oriented sector has shown no change.

Table 6: White collar share in total employment

Year	Export-oriented	Import-competing	Non-tradable	Full sample
1979	0.205	0.258	0.250	0.248
1980	0.216	0.269	0.255	0.258
1981	0.223	0.271	0.254	0.258
1982	0.249	0.298	0.272	0.281
1983	0.228	0.302	0.278	0.282
1984	0.215	0.290	0.270	0.272
1985	0.207	0.281	0.267	0.265
1986	0.236	0.286	0.280	0.278
1987	0.212	0.278	0.288	0.273
1988	0.213	0.289	0.288	0.279
1989	0.194	0.275	0.291	0.270
1990	0.204	0.272	0.288	0.269
1991	0.203	0.278	0.289	0.272
1992	0.205	0.269	0.287	0.267
1993	0.204	0.268	0.288	0.266
1994	0.200	0.272	0.286	0.266
1995	0.208	0.271	0.286	0.267

Table 7 provides further information regarding the evolution of the skill-mix between white and blue collar workers by documenting the evolution of the wage bill share for white-collar workers. In all sectors, the wagebill share has risen more rapidly than the labor share, implying that wage differentials between white and blue collar workers have risen over time. The wage bill share increased by 10% for the import-competing and export-oriented sectors, and 26% for the non-tradable sector over the sample period. As summarized in Table 8, these results imply an annual increase in the wage premium for skilled workers on the order of 0.7% to 1.0% depending on the sector.

Year	Export-oriented	Import-competing	Non-tradable	Full sample
1979	0.303	0.339	0.263	0.304
1980	0.298	0.324	0.260	0.296
1981	0.306	0.343	0.259	0.304
1982	0.337	0.374	0.293	0.336
1983	0.343	0.381	0.296	0.341
1984	0.335	0.377	0.293	0.336
1985	0.332	0.379	0.294	0.338
1986	0.347	0.371	0.310	0.343
1987	0.334	0.380	0.330	0.354
1988	0.331	0.381	0.327	0.354
1989	0.327	0.377	0.338	0.356
1990	0.348	0.380	0.345	0.362
1991	0.351	0.385	0.348	0.366
1992	0.340	0.380	0.344	0.361
1993	0.336	0.379	0.335	0.357
1994	0.312	0.386	0.335	0.357
1995	0.330	0.374	0.332	0.352

Table 7: White collar share in total wagebill

	Export	Import	Non-tradable	Full sample
Wage premium – White-to Blue-collar.	0.9	0.7	1.0	0.8

Table 8: Average annual growth rate 1979-1995

Finally, we conclude our section on descriptive statistics by providing some summary measures of the amount of job creation and destruction occurring in each sector of Chilean manufacturing. While such measures are not central to the questions we address, they provide further information that export-oriented plants behave differently than import-competing plants, and that such differences may have important implications for the overall evolution of labor market conditions as developing economies experience further trade liberalization.

To study job flows, we follow the general setup introduced by Davis and Haltiwanger (1992) to compute measures of job destruction and job creation. Denoting total employment at plant i and year t as x_{it}. Then, plant average employment is given by

$$x_{et} = \frac{1}{2}\left(x_{it} + x_{it-1}\right)$$

and the growth rate of employment, g_{et} is determined by:[7]

$$g_{et} = \frac{(x_{it} - x_{it-1})}{x_{et}}$$

Using the average employment and its growth rate at the plant level, gross job creation (POS_{jt}) and job destruction rates (NEG_{jt}) in sector j at time t can be computed by:

$$POS_{jt} = \sum_{e \, \epsilon \, E_{jt}, \, g_{et}>0} \left(\frac{x_{et}}{X_{jt}} \right) g_{et}$$

$$NEG_{jt} = \sum_{e \, \epsilon \, E_{jt}, \, g_{et}<0} \left(\frac{x_{et}}{X_{jt}} \right) |g_{et}|$$

where, E_{jt} is the set of plants belonging to sector j at t; and, X_{jt} is average employment for sector j. The gross job reallocation rate in sector j between years $t{-}1$ and t is given by $SUM_{jt} = POS_{jt} + NEG_{jt}$. The net growth rate is measured as the difference between POS_{jt} and NEG_{jt}. MAX_{jt} is computed as the maximum of POS_{jt} and NEG_{jt}. SUM_{jt} and MAX_{jt} are usually interpreted as upper and lower bounds for worker reallocation needed to accommodate job reallocation. Table 9 shows the net and gross employment growth rates averaged by trade orientation for total employment, blue-collar and white-collar.

Table 9: Job creation and job destruction by trade orientation

	POS	NEG	NET	SUM	MAX
Total employment					
Export	0.111	0.097	0.020	0.20	0.120
Import	0.087	0.065	0.028	0.15	0.097
Non-tradable	0.075	0.059	0.021	0.13	0.082
White collar					
Export	0.142	0.121	0.029	0.26	0.150
Import	0.127	0.104	0.030	0.22	0.134
Non-tradable	0.126	0.104	0.030	0.22	0.128
Blue collar					
Export	0.111	0.097	0.020	0.202	0.123
Import	0.087	0.065	0.028	0.148	0.098
Non-tradable	0.075	0.059	0.021	0.130	0.082

[7] A desirable property of this formulation is that is bounded by -2 and 2. Thus, a birth of a plant is defined by $g_{et} = 2$ and a death by $g_{et} = -2$.

As mentioned by Levinsohn (1996,1998), there is a political economy concern of trade liberalization. From Table 9, we can see that, when looking at total employment, job creation and destruction were the highest for export-oriented plants following trade liberalization. Twenty percent of all jobs were reallocated in the export-oriented sector, compared to 15% and 13% for import-competing and non-tradable plants. This suggests that trade liberalization seems to create a high level of uncertainty in terms of employment movements, even among those who might expect to gain the most. Also, similar to studies for developed economies, gross job flows exceed by far net job flows, indicating that there is much more reallocation of jobs than the net job growth rates uncover. White and blue collar employment display in general the same patterns. Again, export-oriented plants are among those with the highest destruction and creation rates. The gross job reallocation rate is always higher for white collar than blue collar for all subgroups.

To summarize the results so far, we have found that plants in the export-oriented sector expanded more rapidly than plants in the import-competing and non-tradable sectors both at the plant-level and as a share of manufacturing output and employment. While both the export-oriented and non-tradable sectors saw a rise in output per unit of capital higher than the overall increase, the import-competing sector became relatively more capital intensive by this metric. All three sectors showed increases in the demand for skilled workers relative to unskilled workers as measured by the wage bill share, with the largest increase occurring in the non-tradable sector (26%). The rise in the wage bill for export-oriented and import-competing firms are comparable – on the order of 10% for each sector. To the extent that skill-bias technological change is linked to capital accumulation, the evidence here suggests a more nuanced view of the role of capital-skill complementarity. To rationalize an equivalent increase in the wage bill share of skilled workers for the import-competing and export-oriented sectors in the face of differential changes in capital intensity, it must be the case that capital-skill complementarity is to some extent sector specific. We consider this issue in the next section where we examine the determinants of the skill mix in more detail.

4 Empirical determinants of the wagebill share

We begin our empirical analysis of the determinants of the demand for skilled workers relative to unskilled workers by decomposing the overall change in the labor share of skilled workers relative to total workers, ΔS_t, into within versus between industries shifts in employment.

One of the arguments in favor of SBTC is that the shifts in the share of skilled workers in total employment and in the total wage bill take place within, rather than, between industries. The decomposition of the change in the labor share over a period of time is given by:

$$\Delta S_t = \sum_i \Delta s_{it} E_{i.} + \sum_i \Delta E_{it} s_{i.} \qquad (1)$$

where, s_{it} is the share of white-collar labor in total employment for industry i and year t, and E_{it} is the share of industry i's employment in the aggregated total employment in year t. $E_{i.}$ and $s_{i.}$ denote industry means over time for E_{it} and s_{it}, respectively. The first term on the right hand side of equation 1 measures the within variation, while the second represents the between contribution to the total change in the share ΔS_t. We compute an analagous decomposition for the wage bill share. These results are summarized in Table 10.

For the full sample, the increase in the labor share is positive (0.02) and most of this increase is accounted for by within industry variation rather than between industry variation, consistent with the notion of SBTC. These results also hold across sectors, with the largest increase occurring in the non-tradable sector (0.036). As noted earlier, we see a much larger increase in the wage bill share than the employment share for the full sample, though again most of the variation is explained by within industry movements. For both the export-oriented and import-competing sectors, the within industry variation explains the largest fraction of the change in the wage bill. In contrast to the other two sectors, a substantial fraction of the rise in the non-tradables wage bill share is explained by between industry variation however. With this latter result as a potential exception, these results are broadly consistent with the notion that the relative shift towards skilled workers is due to SBTC.

Table 10: Decomposition of relative labor shifts, 1979-1995

	White collar wagebill share	White collar total employment share
Full sample		
sum	0.049	0.020
within	0.032	0.014
between	0.017	0.006
Export		
sum	0.027	0.003
within	0.020	0.0026
between	0.007	0.0004
Import		
sum	0.0171	0.0128
within	0.0151	0.0089
between	0.0020	0.0039
Non-tradable		
sum	0.060	0.036
within	0.024	0.027
between	0.036	0.009

4.1 Regression analysis: Cost minimization approach

We now consider a more structural analysis of the determinants of the wage bill share at the plant level. In the presence of SBTC, we expect the wage bill share to be correlated with measures of technology adoption at the plant level. To the extent that capital and skilled labor are complements in the production function, we also expect the wage bill share to be positively related to capital intensity. This would be particularly true if new capital goods embodied new technologies that required high-skill workers. To analyze the relationship between labor composition, technology adoption and capital intensity, we adopt a cost minimization approach where capital is assumed to be quasi-fixed and plants minimize the cost of unskilled and skilled labor. We assume constant returns to scale in production and consider a restricted translog variable cost function for plant i in year t, which results in the following expression for the share of skilled labor in the wage bill:

$$Share_{it} = \alpha + \beta \ln\left(\frac{w_{it}^s}{w_{it}^u}\right) + \gamma \ln\left(\frac{K_{it}}{Y_{it}}\right) + \delta Tech_{it} + \varepsilon_{it} \qquad (2)$$

In equation 2, w_{it}^s and w_{it}^u are wages for skilled and unskilled labor, K_{it} is capital, Y_{it} is value added. The coefficient γ measures the extent to which capital and skilled labor are complements. In addition to varying in their wage structure and capital intensity, plants vary in their access to and use of technology. We therefore also include $Tech_{it}$, a vector of observable technology measures, as additional controls in the regression. Equations of this form have been estimated in other studies linking technology changes and employment structure for developed countries (see Machin and Van Reenen (1998) and Berman, Bound and Machin (2000)) and developing economies (Pavnkik (2002b)).

To control for unobserved shocks to the relative demand for skilled workers, we include time, industry and location dummies. Industry dummies are constructed using a 4-digit industry classification. Given that relative wages are highly endogenous, they are not included in the estimating equation. Rather, relative wages are replaced by industry-specific time dummies.

The equation to be estimated is:

$$Share_{it} = \alpha + \gamma \left(\frac{K_{it}}{Y_{it}} \right) + \delta_1 fta_{it} + \delta_2 m_{it} + \eta Year + \theta Location_i + \mu Industry_j + \varepsilon_{it} \quad (3)$$

where, fta_{it} and m_{it} are the proxies for technology use. fta_{it} measures the share of expenses in foreign technical assistance relative to the value added and m_{it} is the share of imported materials in total materials. Both of these measures have been used by Pavnik (2002b) in her analysis of the wage share over the period 1979-1986.[8] If capital is complementary to skilled workers, γ should have a positive sign. Results are presented in Tables 11 and 12.

For the full sample, the results in Table 11 indicate that capital deepening is related to a higher demand for skilled workers. In particular, the coefficient on the share of capital to value added is positive and significant, suggesting the existence of capital-skill complementarity for the full sample. Running the regression for each subgroup according to trade orientation however, gives us mixed results. In the import-competing and non-tradable sectors, we find that additional capital induces a higher demand for skilled workers – the estimated values of γ is positive and significant at the 1% level. For the export-oriented sector, the estimated parameter is negative but not significant implying that there is no evidence of capital-skill complementarity in that sector.

The results in Table 11 also indicate that plants that use imported materials, and license and foreign technical assistance have a higher share of skilled workers. All the coefficients are positive and significant for the subgroups as well as for the full sample. A distinction

[8] Other studies have included R&D intensity as an additional control. Our data set does not contain such information however.

has to be made with respect to the relevance of the foreign technical assistance variable, which according to the results has a significantly stronger effect in the import-competing sector relative to the other two sectors ($\delta_1 = 0.10$ for the import-competing versus $\delta_2 = 0.05$ for the export-oriented and non-tradable sectors).

Table 11: Regressions for skilled labor share in wagebill

	Export-Oriented	Import-Competing	Non-Tradable	Full sample
$\ln(\frac{K_{it}}{VA_{it}})$	-0.042*	0.031**	0.049**	0.029**
	(0.022)	(0.013)	(0.013)	(0.009)
m	0.101**	0.094**	0.117**	0.099**
	(0.009)	(0.003)	(0.006)	(0.003)
fta	0.046**	0.095**	0.047**	0.072**
	(0.015)	(0.006)	(0.007)	(0.004)
R^2	0.27	0.23	0.57	0.42
n. obs	9,831	16,585	14,555	34,644

All regressions include time, location and 4-digit industry dummies.
Robust standard errors are reported in parenthesis.
** and * indicates significance at 5% and 10% level.

The results reported in Table 11 are consistent with other studies and we are controlling for unobserved characteristics at the 4-digit industry level; it is also of some interest to determine to what extent the effects are robust to allowing for unobserved plant-level heterogeneity. Accordingly, we report estimates that include plant fixed effects in Table 12. For the full sample, the estimates of the coefficients on the technology measures are again positive and statistically significant, but there is no longer evidence in favor of capital-skill complementarity. Dissimilar results are found for the different subgroups. The estimated coefficients on the proxies for technology use are no longer positive nor significant for all subgroups. After controlling for plant heterogeneity, the import-competing sector still shows a positive relationship between capital intensity and skill levels. This suggests that the positive relationship between skills and capital intensity for import-competing plants is a highly robust finding. For the export-oriented sector, only the positive effect of imported materials on skill upgrading remains. The other two coefficients become statistically insignificant. For the non-tradable sector, there is also no longer evidence to support capital-skill complementarity nor SBTC.

Table 12: Plant Fixed effect regressions for skilled labor share in wagebill

	Export-Oriented	Import-Competing	Non-Tradable	Full sample
$\ln(\frac{K_{it}}{VA_{it}})$	-0.026	0.019*	0.005	0.006
	(0.027)	(0.010)	(0.014)	(0.009)
m	0.011*	0.006**	0.0003	0.006**
	(0.006)	(0.002)	(0.005)	(0.002)
fta	0.009	0.015**	0.009	0.011**
	(0.008)	(0.006)	(0.006)	(0.004)
R^2	0.03	0.09	0.04	0.07
n. obs	9,831	16,585	14,555	34,644

All regressions include time and plants indicators.
Robust standard errors are reported in parenthesis.
** and * indicate significance at 5% and 10% level

We now consider a specification that pools all plants but allow for sectoral-specific interaction effects. This specification also allows us to directly test for differences in coefficients across sectors. We report these results in Table 13. The first column is a simple OLS regression, the second column is the within-plant estimator that allows for fixed effects. The base group is the import-competing sector.

The results in Table 13 are largely consistent with the results in Table 11. Relative to the import-competing sector, the evidence for capital-skill complementarity is much weaker in the export-oriented sector, either with or without controlling for fixed effects. In the regression without fixed effects, the difference is sizeable – a 1% increase in capital intensity for import-oriented firms relative to export-oriented firms would lead to a 0.1% rise in the relative demand for skilled workers for the import-oriented sector. For the non-tradable sector, we find no evidence of a differential impact of capital intensity in the regression without fixed effects, and some evidence with fixed effects. For the measures of technology adoption, foreign trade assistance has a stronger effect for import competing relative to export-oriented and non-tradable. The effect of the share of imported materials is not statistically different for the export-oriented sector, but stronger for plants belonging to the non-tradable sector. Consistent with the findings in Table 12, these differences are substantially muted once we control for fixed effects.

Table 13: Determinants of wagebill share with interaction effects.		
	Without Fixed Effects	With Fixed Effects
$\ln(\frac{K_{it}}{VA_{it}})$	0.040**	0.026**
	(0.013)	(0.013)
$\ln(\frac{K_{it}}{VA_{it}}) * \exp$	-0.109**	-0.044**
	(0.03)	(0.02)
$\ln(\frac{K_{it}}{VA_{it}}) * notrad$	-0.0003	-0.035
	(0.018)	(0.18)
m	0.094**	0.007**
	(0.003)	(0.003)
$m * \exp$	0.014	0.003
	(0.009)	(0.009)
$m * notrad$	0.021**	-0.0042**
	(0.006)	(0.005)
fta	0.095**	0.014**
	(0.004)	(0.006)
$fta * \exp$	-0.050**	-0.007**
	(0.017)	(0.015)
$fta * notrad$	-0.046**	-0.006**
	(0.009)	(0.008)
R^2	0.42	0.02
n. obs	34,644	34,644

All regressions include time, location and 4-digit industry dummies.
Robust standard errors are reported in parenthesis.
** and * indicate significance at 5% and 10% level

In summary, the results in this section suggest that there is a robust link between technology adoption and the wage bill share for import-competing plants, and weaker evidence for the export-oriented and non-tradable sectors. In terms of capital-skill complementarity, we find a strong differential effect across sectors. The import-competing sector shows substantially greater degree of capital-skill complementarity than the other sectors. The export-oriented sector shows no evidence of capital-skill complementarity. This disparate response across sectors in the effect of capital on the skill mix may help explain why in the aggregate, all three sectors exhibited an increase in the wage bill share of skilled workers with very different response of overall factor intensities. The finding that capital-skill complementarity is strongest for the import-competing sector is also consistent with the view that, following trade liberalization, import-competing firms upgraded their technology and increased their demand for skilled workers partially through a mechanism that is linked to capital accumulation.

5 Conclusions

In this paper we document the evolution and composition of labor in Chilean manufacturing over the period 1979-1995. By sorting the data in export-oriented, import-competing and non-tradable categories we examined the effect of trade liberalization on labor composition. In particular, the share of white collar workers in total employment is higher in the import-competing sector relative to the export-oriented sector. The average share of skilled labor in total plant employment increases by 8%, whereas the average wage bill share of skilled workers rise by 16% during the period 1979-1995. Most of the shifts in these two variables took place within industries, one of the arguments in favor of skill biased technical change.

When looking at job creation and destruction rates, the evidence was similar to the one found for developed economies. Jobs are simultaneously created and destroyed, being job reallocation as prevalent as in advanced economies. White and blue collar employment display in general the same patterns and when the sample is decomposed by trade orientation. The export-oriented sector showed the highest rates of job creation and destruction, suggesting that uncertainty in terms of employment changes is particularly relevant in this case.

We used a cost minimization approach to analyze the relationship between the share of skilled workers in the wage bill, capital deepening and technology adoption. After controlling for unobserved plant heterogeneity, we conclude that there is strong evidence of skilled labor-capital complementarity and SBTC in the import-competing sector, weaker evidence of SBTC for export-oriented plants and less conclusive results for the non-tradable sector. Overall, our results imply that a combination of skill biased technological change and capital skill complementarity are likely candidates to explain labor composition and evolution, especially in the import-competing sector. Finally, our plant-level regression analysis imply that the degree of capital-skill complementarity is sector-specific. This finding highlights the desirability of using plant-level data to assess the determinants driving the changing skill mix over time.

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