Trade Orientation and Labor Market Evolution: Evidence from Chilean Plant-level Data

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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 percent. Between 1973 and 1979, Chile eliminated the quantitative restrictions and reduced the import tariff to a uniform level of 10 percent. A debt crisis in 1982 led to the delay or partial reversal of some reforms (the import tariffs were temporarily increased to 35 percent in 1984), but by 1992 all of them were successfully in place.

Such dramatic changes in the free-trade environment should 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

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the adoption of new technologies or a shift toward importing high-technology capital goods that complement skilled labor. In this case, trade liberalization may lead to rising capital-labor ratios and a shift toward 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 this skill bias is transmitted across countries following trade liberalizations. Empirical evidence for member countries of the Organization for Economic Cooperation and Development (OECD) suggests that unskilled workers experienced a deterioration in their wages over the last two decades despite their increasing relative scarcity. Most industries in these countries saw an increasing participation of skilled workers in the labor force despite the fact that their wages have increased or remained stable relative to unskilled workers.

The evolution of the wage structure in developed countries has become an important research topic 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 the United Kingdom and only a moderate increase in countries like Japan, Sweden, and Germany (Machin and Van Reenen, 1998).

This literature advances several hypotheses to explain the increased demand for skilled relative to unskilled workers in developed economies, 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 the relative demand for skilled versus unskilled workers in developed economies is the presence of pervasive skill-biased technological change.

Only a few studies analyze changes in wage and labor structure in developing economies. For the case of Mexico, the findings suggest that returns to higher education increased between the late 1980s and mid-1990s (Meza, 1999) and that the shifts in the relative demand for skilled workers have taken place mostly within industries. Cragg and Epelbaum (1994) find evidence to support capital-skill complementarity in explaining the increase in the wage dispersion. Hanson and Harrison (1999) explain the increase in wage inequality in Mexican firms in the late 1980s by arguing that the reduction in

1. See Katz and Autor (1999) for a survey.

trade protection that took place in 1985 affected relatively low-skilled industries, which received high trade protection before the liberalization process. Revenga (1997) finds similar results. Robbins (1994, 1999) presents evidence of higher wage inequality following trade liberalization in the case of Chile. For Colombia, the results are mixed: wage disparity initially fell following the trade reform, but the relative wage for skilled workers increased after 1987.

Cross-country analyses provide some evidence of skill-biased technical transfer. Berman and Machin (2000), using data for middle-income countries, find increasing demand for skilled workers, which is concentrated in the same industries as in developed countries and is highly correlated with indicators of OECD technical change. Robbins (1995) points to 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, Pavcnik (2002b) examines the evolution of the white-collar share for Chilean manufacturing plants over the period 1979–86. Pavcnik 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 1979–95. This extended data is well suited to analyzing long-run trend issues, such as the evolution of the skill bias in the Chilean labor market following such significant economic reforms. Unlike Pavcnik, we also disaggregate the data by trade orientation, classifying firms by whether they are in export-oriented, import-competing, or nontradable sectors. In this way, we examine and compare the evolution of labor composition, wage premiums for skilled workers, the role of skill-biased technological change, and capital-skill complementarity across sectors with different trade orientations.

Skill-biased technological change is often linked to the adoption of new technologies through imported inputs following trade liberalization. The ability to adopt such technologies may be sector specific, in which case we expect to see systematic differences in the demand for skilled workers, as well as the evolution of the skilled-worker share across sectors classified by trade orientation. Dividing our sample based on trade orientation also provides a way of measuring the degree to which rising demand for skilled workers is broad-based or narrowly focused. To the extent that different sectors have different relative demands for skilled workers, our sectoral analysis also helps us understand the degree to which aggregate labor market outcomes may be influenced by economic fluctuations and economic policies that directly influence relative sectoral demands.

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 1979–95. Our findings imply that rising demand for skilled workers is broad-based but somewhat uneven. The wage-bill share for white-collar workers rose in all three sectors of manufacturing. The nontradable sector shows the largest increase. The effect of a sharp rise in the white-collar share for the nontradable sector is diminished somewhat in the aggregate, as manufacturing production activity shifted away from nontradables toward exports over this period.

After completing this descriptive exercise, we consider a more formal analysis of the relation between trade orientation 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 skill-biased technological change in both developed economies (Berman and Machin, 2000) and developing economies (Pavcnik, 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, occurred within rather than between industries. This finding provides preliminary support for the existence of skill-biased technological change. Our regression analysis provides evidence that the white-collar wage share is strongly associated with measures of technology adoption across all three sectors of manufacturing. These results offer further evidence in favor of skill-biased technological change.

Our results also suggest that capital-skill complementarity is a determinant of the wage-bill share for import-competing industries. This finding is buttressed by the fact that the import-competing sector exhibited more capital deepening than the export-oriented and nontradable sectors over this period. As a caveat, however, we note that our coefficient estimates imply that the size of the capital-skill complementarity is economically small. In addition, we find little evidence that capital-skill complementarity affects the relative demand for skilled workers in the export-oriented and nontradable sectors. Since the nontradable sector showed the sharpest rise in both the wage-bill share and the wage premium for skilled workers, our findings suggest that pure capital-skill complementarity is unlikely to be the primary driving force behind skill-biased technological change. Rather, more general forms of technological adoption are likely explanations for the rising demand for skilled workers in Chile over this time period.

The paper is organized in the following way. Section 1 gives a brief summary of the empirical evidence in favor of skill-biased technological change in developed economies. Section 2 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 3, we provide a more formal analysis of the evolution of the mix of skilled and unskilled worker: 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 relation between labor composition, capital deepening, and technology adoption. Section 4 concludes.

1. Empirical Evidence in Favor of Skill-biased Technological Change

The empirical evidence for the United States and OECD countries suggests that less-skilled workers experienced a decrease in relative wages along with increasing unemployment rates during the 1980s. In the United States, real wages for young men with twelve or fewer years of education fell by 26 percent between 1979 and 1993, without signs of recovery since. Similar patterns characterized the evolution of relative wages of less-skilled workers in several OECD countries. It is a well-documented fact that labor market outcomes for less-skilled workers in developed economies deteriorated in the past two decades despite the increasing relative supply of skilled workers.

Two hypotheses have been analyzed to explain the evolution of labor composition in developed economies: the Stolper-Samuelson mechanism and skill-biased technological change. The standard Heckscher-Ohlin model predicts that when a skill-abundant country like the United States trades with less-skill-abundant developing countries, the skill-abundant country will experience an increase in the relative price of the skill-intensive good, which translates into an increase in the relative wage of skilled workers. An alternative explanation is pervasive skill-biased technological change, in which the economy experiences an increase in the proportion of skilled labor and relative wages, as well as within-industry skill upgrading. According to this hypothesis, the presence of pervasive, sector-neutral, skill-biased technological change is a potential explanation for the existence of an increasing skilled-unskilled wage premium even in the case of a small open economy. It is important to notice that, unlike the Stolper-Samuelson effect, pervasive skill-biased technological change induces within-industry increases in the share of skilled workers employed.

So far, empirical research suggests that the main explanation behind the evolution of relative labor and wages in the developed world is pervasive skill-biased technological change. The arguments in favor of this hypothesis can be summarized as follows: (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. Table 1 presents the annualized change in employment and wage-bill shares for a group of developed economies.

For a developing economy like Chile, the Stolper-Samuelson mechanism implies the opposite effect in terms of the wage premium. In particular, a less-developed country like Chile that trades with skill-abundant developed economies should experience a decrease in the labor share of skilled workers and a change in the relative wage in favor of unskilled workers. According to the evidence presented in

Table 1. Skilled to Unskilled Labor and Wage-bill Shares: Developed Economies, 1980–90
Percent

	Country						
Indicator	*United States*	*United Kingdom*	*Japan*	*Sweden*	*Denmark*	*Austria*	*Belgium*
Annual change in labor share	0.30	0.29	0.06	0.12	0.41	0.16	0.16
—Within-industry share (% of total change)	73	93	123	60	87	68	96
Annual change in wage-bill share	0.51	0.62	0.14	0.07	0.64	0.36	−0.06
—Within-industry share (% of total change)	76	92	84	25	89	76	92
Change in wage ratio, 1980–90	7	14	3	−3	7	7	−5

Source: Berman, Bound, and Machin (1998).

this paper, the labor and wage-bill shares for Chilean manufacturing plants went in the opposite direction, an observation that is inconsistent with the classical Stolper-Samuelson explanation of exposure to trade. With this in mind, we analyze whether the presence of skill-biased technological change is a plausible explanation for the change in the labor composition and relative wages in the Chilean economy between 1979 and 1995.

2. Data Overview

Given the macroeconomic volatility and structural changes that occurred over this period, the use of 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 only considers information between 1979 and 1986.[2] The topics analyzed are 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 evolution of the relative demand for skilled workers.[3]

Our current set of plant-level data for Chilean manufacturing plants was obtained from the World Bank and the National Statistics Institute of Chile (INE); the data were collected by INE. In the cleaned sample, we have an average of 3,906 plants per year with ten or more employees in the manufacturing sector. The data set contains annual information for the period 1979–95, and it 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. After the elimination of extreme outliers, this panel data contains 66,406 observations across plants and years.

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

3. Pavnik (2002a), using information for Chilean industrial plants, concludes that productivity increased by 3–10 percent in the import-competing sector as a result of trade liberalization, but findings for the export-oriented sector are not conclusive. Liu and Tybout (1996) and Tybout (1996) use the 1979–86 sample to study productivity dynamics at the plant level while Levinsohn (1996) study job creation and destruction based on this data set.

We constructed appropriately defined capital indices using the perpetual inventory method, aggregated material inputs using 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 relation between employment composition according to skill level, trade orientation, and technology adoption, we needed proxies for the technology measure. The proxies for technology use provided by the data are imported materials and expenditures on foreign technical assistance. Unfortunately, we do not have information on foreign direct investment or on expenditures on research and development, which are the variables commonly chosen as ideal proxies for technology measures.

2.1 Sectoral Classification

To classify plants based on their trade orientation, we rely on information on imports and exports from the World Trade Analyzer CD-ROM from Statistics Canada. The level of disaggregation in the information obtained from Statistics Canada allowed us to improve on previous definitions provided by Liu (1991) by updating the information between 1987 and 1995. In particular, plants that belong to a three-digit industry in which more than 15 percent of the industry's output is exported were characterized as export-oriented plants. Likewise, plants in an industry in which the ratio of total imports to total domestic output is higher than 15 percent were characterized as import-competing. The remaining plants were classified as belonging to the nontradable sector.

Table 2 summarizes the sectoral classification across three-digit industries, while tables 3, 4, and 5 document the evolution of plant size and the share of manufacturing value-added and employment accounted for by each sector. Unsurprisingly, table 2 indicates that export-oriented industries are concentrated in wood, paper, and mining, while import-competing industries are much more heterogeneous.

Table 3 provides the sample means for the number of employees per plant, for both the full-sample and the subsamples in which 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 were 26 percent larger than the average plant,

Table 2. Industrial Composition of Sectors by Trade Orientation
Percent

Code	Description	Sector: Export-oriented	Import-competing	Nontradable
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 products	–	–	100
355	Rubber	–	–	100
356	Plastics	–	100	–
361	Ceramics	–	100	–
362	Glass	–	100	–
369	Nonmetallic minerals	–	–	100
371	Iron and steel	–	–	100
372	Nonferrous metals	100	–	–
381	Metal products	–	100	–
382	Nonelectric machinery	–	100	–
383	Electric machinery	–	100	–
384	Transport equipment	–	100	–
385	Professional equipment	–	100	–
390	Miscellaneous	–	100	–

Source: Authors' calculations.

while in 1995, this size discrepancy had increased to 46 percent. At the beginning of the sample, import-competing plants were also significantly larger than plants in the nontradable sector. This difference erodes over time, however. Using labor as a measure of size, the overall finding from table 3 is that plant size in the export-oriented sector appears to have expanded much more than plant size in other sectors.[4]

The increase in plant size for export-oriented firms occurred in conjunction with an overall expansion of the export-oriented sector relative to the other two sectors. Table 4 documents the share of value-added

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

accounted for by plants in each sector. According to our sample, the export sector's share of value-added rose from 14 percent to 19 percent over the sample period. The import-competing share increased slightly and the nontradable share fell almost 20 percent during this time. The import-competing sector, however, accounts for the largest component of manufacturing economic activity—on the order of 50 percent.

Table 5 documents the share of manufacturing employment accounted for by each sector. For the export-oriented sector, the employment share shows an increase similar to that of the value-added share. In contrast to the value-added share, however, the employment share for the import-competing sector fell somewhat over this period. The employment share for the nontradable sector also fell, though the drop is muted relative to the drop in the value-added share of this sector.

2.2 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 1980s when the rest of the manufacturing sector was mired in recession. Over the full sample period, the import-competing sector grew faster, at 6.2 percent annually, than the export-oriented and nontradable sectors, which grew at 5.6 percent and 5.1 percent, respectively.

Table 3. Mean of Total Employment in Plants by Sector

	Sector			
Year	*Export-oriented*	*Import-competing*	*Nontradable*	*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

Source: Authors' calculations.

Table 4. Value-added Share by Sector

Year	*Sector* Export-oriented	Import-competing	Nontradable
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

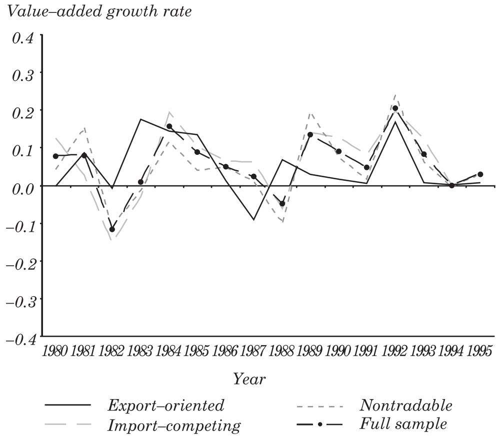
Source: Authors' calculations.

Table 5. Total Employment Share by Sector

Year	*Sector* Export-oriented	Import-competing	Nontradable
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

Source: Authors' calculations.

Figure 1. Value-added Growth



Source: Authors' calculations.

The overall growth rate for our manufacturing sample was 5.8 percent over this period.[5]

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 1979–95 period, while table 6 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 percent, and least rapidly in the nontradable sector, at 2.2 percent on average. Capital productivity grew rapidly for the export and nontradable sectors, at an average annual rate of 3.3 percent and 4.2 percent, respectively. Measured by output per unit of capital, the import-competing sector saw a substantially greater increase in capital

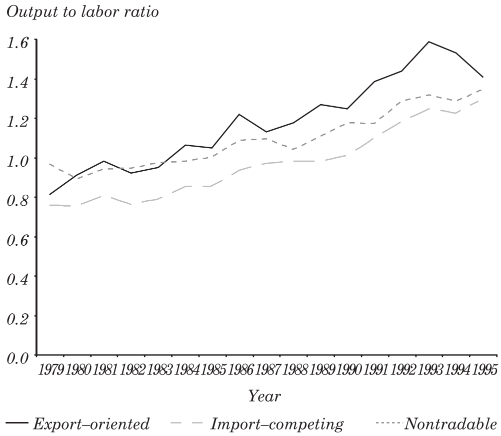
5. Because our data is a sample rather than the full universe of manufacturing plants, we measure growth rates for plants that are in the sample over consecutive periods. Let n_{t-1} denote the set of plants with observations available for both t and $t-1$. The growth rate of value-added is then computed as

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

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 and capital-output ratios and the total factor productivity numbers documented in figure 3 and table 6. We thus treat these numbers as informative rather than definitive. The labor productivity numbers are not subject to such potential biases.

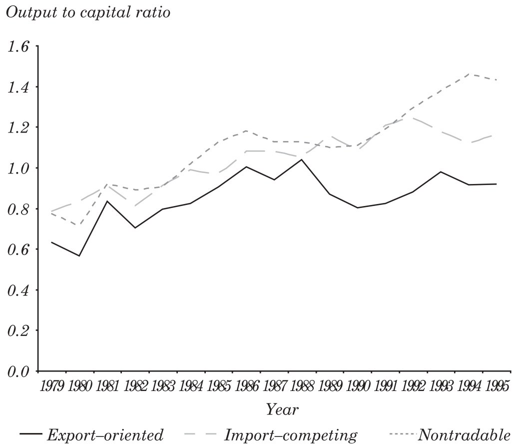
intensity relative to the other two sectors over this period. The finding that the import-competing sector became more capital intensive relative to the other two sectors over time is consistent with the notion that trade liberalization allowed import-competing firms to increase their capital intensity through the adoption of imported machinery. When

Figure 2. Labor Productivity



Source: Authors' calculations.

Figure 3. Capital Productivity



Source: Authors' calculations.

Table 6. Average Annual Growth Rate by Sector, 1979–95
Percent

Indicator	*Sector*			*Full sample*
	Export-oriented	*Import-competing*	*Nontradable*	
Output to capital	3.3	2.7	4.2	3.3
Output to labor	3.8	3.5	2.2	2.9
Labor to capital	–0.5	–0.8	2.0	0.4
Total factor productivity	3.6	3.2	2.9	3.1

Source: Authors' calculations.

we measure total factor productivity as a weighted average of labor and capital productivity, these numbers imply substantial gains in productivity for the export-oriented sector relative to the import-competing and nontradable sectors.

2.3 Labor Composition by Sector

We now document trends in labor composition between skilled and unskilled workers. Table 7 summarizes the evolution of the white-collar share of total employment. Here we report the ratio of white-collar employees in each sector to 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 nontradable sectors. The overall share of skilled workers in total employment displays moderate increases over time, showing a rise of 8 percent for the full sample in the period 1979–95. In contrast to the import-competing and nontradable sectors, the white-collar share of employment in the export-oriented sector shows no change.

Table 8 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 wage-bill share rose more rapidly than the labor share, implying that wage differentials between white- and blue-collar workers rose over time. The wage-bill share increased by 10 percent for the import-competing and export-oriented sectors and by 26 percent for the nontradable sector over the sample period. As summarized in table 9, these results imply an increase in the wage premium for skilled workers for the period 1979–95 on the order of 9–16 percent, depending on

Table 7. White-collar Share in Total Employment by Sector

Year	Sector			Full sample
	Export-oriented	*Import-competing*	*Nontradable*	
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

Source: Authors' calculations.

Table 8. White-collar Share in Total Wage Bill by Sector

Year	Sector			Full sample
	Export-oriented	*Import-competing*	*Nontradable*	
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

Source: Authors' calculations.

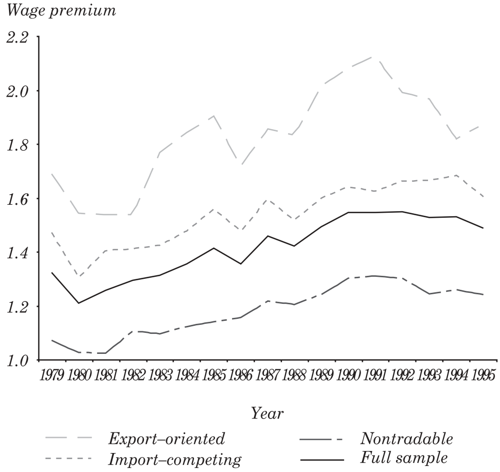
Table 9. Skilled-to-unskilled-labor and Wage Bill Shares: Chilean Manufacturing, 1979–95

Percent

Indicator	*Sector*			*Full sample*
	Export-oriented	*Import-competing*	*Nontradable*	
Annual change in labor share	0.32	0.37	0.87	0.45
—Within-industry share	87	70	75	70
Annual change in wage-bill share	0.63	0.66	1.54	0.95
—Within-industry share	74	88	40	65
Change in wage ratio, 1979–95	11	9	16	12

Source: Authors' calculations.

Figure 4. Wage Premium by Sector



Source: Authors' calculations.

the sector.[7] The evolution of the wage premium by trade orientation of the sectors is presented in figure 4. In table 9, the annualized change in the labor and wage-bill shares was higher than for developed economies, based on a comparison with table 1.

7. The decomposition of within- and between-industry shifts is presented in section 3.

3. Empirical Analysis of the Determinants of the Wage Bill Share at the Plant Level

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 nontradable sectors, both at the plant level and as a share of manufacturing output and employment. While both the export-oriented and nontradable sectors saw a higher rise in output per unit of capital 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 nontradable sector (26 percent). The rise in the wage bill for export-oriented and import-competing firms are comparable—on the order of 10 percent for each sector. Since the import-competing sector appears to have experienced the most capital deepening, the sharp rise in the relative demand for skilled workers in the nontradable sector suggests that capital-skill complementarity is not the main driving force behind skill-biased technological change. We consider this issue further in our regression analysis.

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-industry shifts in employment. One of the arguments in favor of skill-biased technological change 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 total aggregate 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-industry variation, while the second represents the between-industry contribution to the total change in the share ΔS_t. We compute an analogous decomposition for the wage-bill share. These results are summarized in table 10.

Table 10. Decomposition of Relative Labor Shifts, 1979–95

Sample and indicator	*White-collar share of wage bill*	*White-collar share of total employment*
Full sample		
Total share	0.049	0.020
Within-industry share	0.032	0.014
Between-industry share	0.017	0.006
Export-oriented		
Total share	0.027	0.0030
Within-industry share	0.020	0.0026
Between-industry share	0.007	0.0004
Import-competing		
Total share	0.017	0.013
Within-industry share	0.015	0.009
Between-industry share	0.002	0.004
Nontradable		
Total share	0.060	0.036
Within-industry share	0.024	0.027
Between-industry share	0.036	0.009

Source: Authors' calculations.

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 skill-biased technological change. These results also hold across sectors, with the largest increase occurring in the nontradable 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, however, a substantial fraction of the rise in the nontradable wage-bill share is explained by between-industry variation. With this latter result as a potential exception, these results are broadly consistent with the notion that the relative shift toward skilled workers is due to skill-biased technological change. For the full sample, shifts in the share of skilled workers are mostly explained by within-industry changes, which represent 65–70 percent of the total variation.

3.1 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 skill-biased technological change, 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 true, in particular, if new capital goods embodied new technologies that required highly skilled workers. We analyze the relation between labor composition, technology adoption, and capital intensity using a cost-minimization approach in which 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 variable translog cost function for plant *i* in year *t*, which results in the following expression for the share of skilled labor in the wage bill:

$$SHARE_{it} = \alpha + \beta \ln\left(\frac{w_{it}^{s}}{w_{it}^{u}}\right) + \gamma \ln\left(\frac{K_{it-1}}{VA_{it}}\right) + \delta TECH_{it} + \varepsilon_{it} \ . \qquad (2)$$

In equation (2), $w_{it}{}^{s}$ and $w_{it}{}^{u}$ are wages for skilled and unskilled labor; K_{it-1} is capital, which is pre-determined; and VA_{it} is value-added. The coefficient γ measures the extent to which capital and skilled labor are complements. Plants vary not only in their wage structure and capital intensity, but also 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 both developed countries (see Machin and Van Reenen, 1998; Berman, Bound, and Machin, 1998) and developing economies (Pavcnik, 2002b).

We include time, industry, and location dummies to control for unobserved shocks to the relative demand for skilled workers. Industry dummies are constructed using a four-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 as follows:

$$\begin{aligned} SHARE_{it} = \alpha + \gamma \ln\left(\frac{K_{it-1}}{VA_{it}}\right) + \delta_1 m_{it} + \delta_2 FTA_{it} + \eta YEAR_t \\ + \theta LOCATION_i + \mu INDUSTRY_j + \varepsilon_{it} \end{aligned} \qquad (3)$$

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 total expenses in services from third parties, and m_{it} is the share of imported materials in total materials. Pavcnik (2002b) uses both of these measures in her analysis of the wage share over the period 1979–86.[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. When interpreted as an elasticity, the size of the coefficient is small in absolute terms, however. It is also small relative to the elasticity for the imported materials share, which, in contrast, is of substantial economic significance—on the order of 0.1 to 0.2, depending on the sector.[9] Running the regression for each subgroup according to trade orientation produces mixed results. In the import-competing and nontradable sectors, we find that additional capital induces a higher demand for skilled workers. 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. In summary, although we found evidence of capital-skill complementarity for import-competing and nontradable plants, the effect is estimated to be economically small, which is consistent with other findings for developed economies.

The results in table 11 also indicate that plants that use imported materials 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 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 and export-oriented sectors relative to the nontradable sector (0.25 and 0.26 versus 0.09). At the same time, imported materials have a stronger effect for nontradable plants.

8. Other studies include R&D intensity as an additional control. Our data set does not contain such information, however.

9. It is possible that the imported materials share is a good proxy for the share of imported capital relative to domestic capital goods. If true, our results imply that complementarities between imported capital and skills are an important determinant of the relative demand for skilled workers. Our findings would still imply that the overall capital intensity is not a significant determinant of the relative demand for skilled workers, however.

The results reported in table 11 are consistent with other studies, and we are controlling for unobserved characteristics at the four-digit industry level. To determine the extent to which the effects are robust to allowing for unobserved plant-level heterogeneity, we report estimates that include plant fixed effects in table 12. For the full sample, the estimate of the coefficient on imported materials is again positive and statistically significant, and there is also evidence in favor of capital-skill complementarity. Dissimilar results are found for the different subgroups.

Table 11. Regressions for Skilled Labor Share in Wage Bill[a]

	Sector			
Explanatory variable	*Export-oriented*	*Import-competing*	*Nontradable*	*Full sample*
$\ln(K_{it-1}/VA_{it})$	–0.0007	0.002*	0.005**	0.003**
	(0.003)	(0.001)	(0.001)	(0.0009)
m_{it}	0.122**	0.168**	0.234**	0.180**
	(0.020)	(0.007)	(0.012)	(0.006)
FTA_{it}	0.262**	0.252**	0.088**	0.178**
	(0.043)	(0.032)	(0.023)	(0.019)
Summary statistic				
Adjusted R^2	0.27	0.20	0.56	0.40
No. observations	3,736	16,966	14,687	35,404

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
a. All regressions include time, location, and four-digit industry dummies. Robust standard errors are reported in parentheses.
Source: Authors' calculations.

Table 12. Plant Fixed Effects Regressions for Skilled Labor Share in Wage Bill[a]

	Sector			
Explanatory variable	*Export-oriented*	*Import-competing*	*Nontradable*	*Full sample*
$\ln(K_{it-1}/VA_{it})$	0.003	0.007**	0.0003	0.004**
	(0.003)	(0.001)	(0.002)	(0.001)
m_{it}	0.040*	0.016**	–0.009	0.010**
	(0.022)	(0.006)	(0.010)	(0.005)
FTA_{it}	0.099	0.026	–0.023	0.004
	(0.066)	(0.022)	(0.021)	(0.014)
Summary statistic				
Adjusted R^2	0.68	0.71	0.80	0.76
No. observations	3,736	16,966	14,687	35,404

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
a. All regressions include time and plant indicators. The adjusted R^2 is obtained by including the estimated group effects on the fit of the model. Robust standard errors are reported in parentheses.
Source: Authors' calculations.

The estimated coefficients on the proxies for technology use are no longer positive and significant for all subgroups. After controlling for plant heterogeneity, the import-competing sector still shows a positive relation between capital intensity and skill levels. Again, the coefficient is estimated to be small in magnitude. 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 nontradable sector, there is also no longer evidence to support either capital-skill complementarity or skill-biased technological change.

We now consider a specification that pools all plants but allows 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

Table 13. Determinants of Wage Bill Share with Interaction Effects[a]

Explanatory variable	*Without fixed effects*	*With fixed effects*
$\ln(K_{it-1}/VA_{it})$	0.004**	0.008**
	(0.001)	(0.001)
$\ln(K_{it-1}/VA_{it})$*$EXPORT_{it}$	−0.006**	−0.005*
	(0.003)	(0.003)
$\ln(K_{it-1}/VA_{it})$*$NONTRAD_{it}$	0.000	−0.010**
	(0.001)	(0.002)
m_{it}	0.168**	0.015**
	(0.007)	(0.006)
$m_{it*}EXPORT_{it}$	−0.034*	0.011
	(0.021)	(0.019)
$m_{it*}NONTRAD_{it}$	0.059**	−0.022*
	(0.014)	(0.011)
FTA_{it}	0.254**	0.028
	(0.033)	(0.022)
$FTA_{it*}EXPORT_{it}$	0.021	0.019
	(0.053)	(0.060)
$FTA_{it*}NONTRAD_{it}$	−0.165**	−0.047
	(0.040)	(0.030)
Summary statistic		
Adjusted R^2	0.40	0.76
No. observations	35,404	35,404

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
a. Robust standard errors are reported in parentheses.
Source: Authors' calculations.

capital-skill complementarity is much weaker in the export-oriented sector, regardless of whether we control for fixed effects. For the nontradable sector, we find no evidence of a differential impact of capital intensity in the regression without fixed effects, but strong evidence when allowing for fixed effects. For the measures of technology adoption, foreign technical assistance has a stronger effect for import-competing relative to nontradable plants. The effect of the share of imported materials is statistically different for the export-oriented sector without controlling for fixed effects. Consistent with the findings in table 12, these differences are substantially muted once we control for fixed effects.

4. Conclusions

This paper has documented the evolution and composition of labor in Chilean manufacturing over the period 1979–95. By sorting the data into export-oriented, import-competing, and nontradable categories, we were able to examine and compare the evolution of labor composition across sectors with different trade orientations. 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 increased by 8 percent, whereas the average wage-bill share of skilled workers rose by 16 percent during the period 1979–95. Most of the shifts in these two variables took place within industries, which is one of the arguments in favor of skill-biased technical change.

We used a cost-minimization approach to analyze the relation between the share of skilled workers in the wage bill, capital deepening, and technology adoption. Consistent with other findings (Pavnik, 2000b), our results suggest a robust link between technology adoption and the demand for skilled workers measured by the wage-bill share. We also find a statistically significant effect of capital intensity on the relative demand for skilled workers in the import-competing sector. This effect is small in economic terms, however. We find no such link for the export-oriented and nontradable sectors. Overall, these results suggest that skill-biased technological change is transmitted through mechanisms other than capital accumulation. Because one of our technology measures, the share of imported materials used in production, is probably correlated with the share of imported capital used in production, our evidence leaves open the possibility that in a free-trade environment, skill-biased technological change may be transmitted to developing countries through the adoption of new machines imported from abroad. Further research is required to say more on this question.

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