WORKING PAPER

IMPLICATIONS OF TECHNOLOGY AND IMPORTS ON EMPLOYMENT AND WAGES IN CANADA

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Industry Canada Industrie Canada

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by Frank C. Lee, Industry Canada

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Comments should be addressed to:

Someshwar Rao
Director, Strategic Investment Analysis
Micro-Economic Policy Analysis
Industry Canada
5th Floor, West Tower
235 Queen Street
Ottawa, Ontario
K1A 0H5

Telephone: (613) 941-8187
Facsimile: (613) 991-1261

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EXECUTIVE SUMMARY

This paper analyses the net effects of technology and import competition on employment, wages and wage inequality in the Canadian manufacturing sector over the period 1970-1990 by estimating reduced-form employment and wage equations. The analysis uses non-production and production workers to distinguish between two categories of labour. For each group, the number of person-hours worked, the level of employment and the hourly labour compensation by industry are examined. The major findings from the study are as follows: (1) the growth of employment and of real hourly labour compensation in the Canadian manufacturing sector is positively related to technical progress and to the price of imports; (2) the relative employment of non-production to production workers is negatively related to technical progress, while the relative real hourly labour compensation of non-production to production workers is positively associated with technical progress; (3) the relative employment of non-production to production workers is negatively related to the price of imports, but the relative real hourly labour compensation of non-production to production workers is positively associated with the price of imports.

1. INTRODUCTION

Canada's trade with the rest of the world has been increasing as a result of reductions in tariff and non-tariff barriers to trade. At the same time, the pace of globalization has accelerated due, in part, to the introduction of new technologies, especially those related to information and communications. Both increased trade and improved technology are expected to have a positive impact on economic growth and employment in the long-run. However, there are mounting concerns that trade and technology are also the main causes of widespread job losses in some sectors or among workers with particular skills. These concerns have been expressed more vocally as developed countries went through a recession in the early 1990s. In the United States, there has been a significant increase in the employment and wages of skilled workers relative to those of less skilled workers during the 1980s. Over the same period, the United States recorded a massive deficit in its external trade. Although the rise in wage inequality has been smaller in Canada, the loss of employment among blue-collar workers coupled with a decline in Canada's trade balance during the recession led some observers to advocate protectionist trade policy and resist the adoption of new technologies. Today, the Canadian economy is in a phase of expansion led by the export sector. However, future recessions characterised by major structural changes will likely invite similar concerns and doubts about trade and technology. Thus, the questions about the manner in which trade and technology affect employment and wages should naturally extend to the analysis of their impact on the distribution of wages and employment.

Many notable empirical papers based on U.S. data have been published on these and other related issues. One class of explanations looks at the factor content of trade by calculating the labour needed to produce exports and the labour displaced by imports at given wages to estimate the impact of trade on employment. The changes in effective employment are then used to determine changes in wages based on estimates of wage elasticities taken from other studies. Borjas, Freeman and Katz (1992) use changes in the volume of trade to estimate the implicit labour supply for different groups (based on sex, education and experience) by calculating the number of person-hours needed to produce exports or imports in various U.S. manufacturing industries. They conclude that the U.S. trade deficit increased the relative supply of less educated workers and, consequently, lowered their relative wages. In a similar fashion, Murphy and Welch (1991) map changes in trade patterns to shifts in labour demand while controlling for variations in domestic spending. They find that qualitative predictions of changes in trade on the employment distribution between industries and on changes in the relative structure of wages are similar in magnitude to those observed for the 1980s. All these empirical studies relate wages and employment to the volume of trade. Yet, this link is not found in the general equilibrium theory of trade. Bhagwati and Dehejia (1994) and Deardorff and Hakura (1994) show that real wages can vary only through changes in factor prices (reflecting a trade-induced change in the prices of goods) or in productivity but not through changes in trade volume.[1] Furthermore, in a small open economy, the volume of trade depends on the behaviour of firms and consumers, whereas international prices do not.

On the other hand, Grossman (1986, 1987), Revenga (1992) and Lawrence and Slaughter (1993) consider import prices as one of the explanatory variables of observed changes in wages and employment. Except for one industry, Grossman (1987) finds little evidence of an impact of import prices on employment. He also observes little wage adjustment to import competition, which probably reflects a relatively high degree of intersectoral labour mobility. However, using a similar approach, Revenga (1992) finds that changes in import prices do have a significant influence on both employment and wages. In contrast, Lawrence and Slaughter (1993) argue that trade has not been the dominant factor in the performance of U.S. average and relative wages during the 1980s. They reason that biased technical change toward non-production workers increased their relative wages and employment. Bound and Johnson (1992) and Berman, Bound and Griliches (1994) also point out the importance of skilled-labour biased technical change as the key culprit shifting away employment from production to non-production workers.

Freeman and Needels (1993) find that earnings differential by education increased much less in Canada than in the United States during the 1980s. They argue that some demand-side factor must have been responsible for the rise in the college wage premium, since there was faster growth in the number of college graduates in Canada. Betts (1994) also finds evidence of biased technical change away from production workers towards energy in Canada based on translog cost function estimates.

As can be seen, there are mixed empirical results about the impact of technology and imports on employment and wages in the United States, and there are only scant empirical findings for Canada. The purpose of this paper is to analyse the impact of technology and imports on wages and employment in the Canadian manufacturing sector using cross-section time-series data over the 1970-1990 period. The remainder of the paper is organised as follows. The estimation model used is described in the next section. Empirical results are discussed in the following section. Finally, our conclusions are presented in the last section. Four appendices provide more details on the data and variables employed, the decomposition equation estimated, the results obtained from unit root tests, and on our empirical results for export intensity and import penetration.

2. EMPIRICAL DESIGN

This section describes the model to be estimated.

The Model

As in Grossman (1986, 1987) and Revenga (1992), we use reduced-form employment and wage equations to estimate the ultimate quantitative effects of technology and imports on employment and wages.[2] We first assume that the output, Y_{it}, of industry *i*, is produced from the vector of non-tradable inputs $\mathbf{X}_{it}$ and the vector of tradable inputs $\mathbf{Z}_{it}$ at time *t*:

$$Y^{s}_{it} = F(g_{it}, \mathbf{X}_{it}, \mathbf{Z}_{it}), \tag{1}$$

where g_{it} denotes the rate of technical progress in industry *i* at time *t*. The function is assumed to be strictly concave exhibiting constant returns to scale.

The value of the marginal product is set to equal its input price. Therefore, the vector of the quantities demanded of non-tradable inputs takes the following form:[3]

$$\mathbf{X}^{d}_{it} = G(P_{it}, Y_{it}, \mathbf{v}_{it}, \mathbf{w}_{it}), \text{ where } G_1 > 0,\ G_2 > 0, \text{ and } G^{j}_{3} < 0,\ j = 1, \ldots, J, \tag{2}$$

where P_{it} is the price of output, $\mathbf{v}_{it}$ is the vector of non-tradable input prices, and $\mathbf{w}_{it}$ is the vector of tradable input prices.

Each non-tradable input, *j*, is assumed to be imperfectly mobile between industries. Thus, the supply of each input can be expressed as a function of its rate of return and of the aggregate rate of return of inputs, $\overline{v}^{j}_{t}$:[4]

$$X^{j}_{it} = H(v^{j}_{it}, \overline{v}^{j}_{t}),\ H_1 > 0,\ H_2 < 0, \text{ and where } j = 1, \ldots, J. \tag{3}$$

This specification allows for the persistence of differences in the rates of return of inputs across industries. There could be several reasons for this. First, workers may have preferences for certain occupations and industries. Second, inputs may be industry-specific such that they cannot be treated as homogenous. Gera and Grenier (1994) provide evidence for interindustry wage differences in Canada. Consequently, our partial equilibrium approach hinges on the assumption that labour is not perfectly mobile across industries. This assumption of separate labour supply for each industry is a minor variation of the specific factor model and differs from the general equilibrium Heckscher-Ohlin model, which assumes perfect intersectoral labour mobility.

The real aggregate rate of return of non-tradable inputs is determined by the aggregate stock of non-traded inputs and the prices of traded inputs:

$$\frac{\overline{v}_t^j}{\overline{P}_t} = \Psi(\overline{\mathbf{X}}_t, \mathbf{w}_{it}), \text{ where } \Psi_1^j < 0, j = 1, \ldots, J, \tag{4}$$

and $\overline{P}_t$ denotes the aggregate price level.

Tradable inputs are assumed to be available in infinitely-elastic supply at their respective exogenous price, $\mathbf{w}_{it}$, since Canada is a small open economy. The vector of the quantities demanded of these inputs is assumed to take the following expression, where it is determined by setting the value of the marginal product equal to its input price:

$$Z_{it}^k = Q(P_{it}, Y_{it}, \mathbf{v}_{it}, \mathbf{w}_{it}), \text{ where } Q_1 > 0,\ Q_2 > 0,\ Q_4^k < 0, \text{ and } k=1, \ldots, K. \tag{5}$$

In order to close the model, we specify the demand faced by each industry. The output of industry *i* is assumed to be imperfectly substitutable with the imported goods (at a price of P_{it}^M and a tariff rate of τ_{it}) competing in the same market and with the aggregate basket of domestic goods. Therefore, the demand facing industry *i* can be expressed as:

$$Y_{it}^d = \Omega(P_{it}^*, P_{it}, \overline{P}_t, \overline{Y}_t),\ \ \Omega_1 > 0,\ \Omega_2 < 0,\ \Omega_3 > 0, \text{ and } \Omega_4 > 0, \tag{6a}$$

where $P_{it}^* = P_{it}^M(1+\tau_{it})$ and $\overline{Y}_t$ is the measure of aggregate output. Equations (1) through (6a) determine the endogenous variables Y_{it} and P_{it}, and vectors, $\mathbf{X}_{it}$, $\mathbf{Z}_{it}$, $\mathbf{v}_{it}$, and $\overline{\mathbf{v}}_t$, as functions of the exogenous variables g_{it}, $\overline{Y}_t$, $\overline{P}_t$ and P_{it}^*, and vectors $\overline{\mathbf{X}}_t$ and $\mathbf{w}_{it}$.

The relative price of imports may not capture the displacement caused by increased imports or decreased exports due to non-tariff barriers or changes in preferences toward imports. Thus, in order to consider these effects, equation (6a) can be alternatively specified as

$$Y_{it}^d = \Phi(X_{it}, M_{it}, \overline{Y}_t), \text{ where } \Phi_1 \geq 0,\ \Phi_2 \leq 0 \text{ and } \Phi_3 > 0, \tag{6b}$$

where X_{it} and M_{it} denote, respectively, the export demands for and the imports competing with the output of industry *i*.

Empirical Specification

To implement the model empirically, we make the assumption that the vector of non-tradable inputs, $\mathbf{X}_{it}$, is composed of capital, K_{it}, skilled labour, S_{it}, and unskilled labour, L_{it}, whose respective prices are r_{it}, w_{it}^S and w_{it}^L. The vector of tradable inputs, $\mathbf{Z}_{it}$, is assumed to include energy, E_{it}, and intermediate goods, I_{it}, whose respective prices are P_t^E and P_t^I. The reduced-form equations for employment ($N_{it} = S_{it}+L_{it}$) and wages (w_{it}) are given by the following expressions after taking natural logarithms:[5]

$$\ln N_{it} = a_0 + a_1 g_{it} + a_2 \ln\left[\frac{P^*_{it}}{\overline{P}_t}\right] + a_3 \ln\left[\frac{P^E_{it}}{\overline{P}_t}\right] + a_4 \ln\left[\frac{P^I_{it}}{\overline{P}_t}\right] + a_5 \ln \overline{K}_t + a_6 \ln \overline{N}_t + a_7 \ln \overline{Y}_t, \tag{7}$$

$$\ln\left[\frac{w_{it}}{\overline{P}_t}\right] = b_0 + b_1 g_{it} + b_2 \ln\left[\frac{P^*_{it}}{\overline{P}_t}\right] + b_3 \ln\left[\frac{P^E_{it}}{\overline{P}_t}\right] + b_4 \ln\left[\frac{P^I_{it}}{\overline{P}_t}\right] + b_5 \ln \overline{K}_t + b_6 \ln \overline{N}_t + b_7 \ln \overline{Y}_t. \tag{8}$$

Alternatively, the reduced-form equations used to analyse the relative employment and wage performance of skilled workers could take the following form:

$$\ln\left[\frac{S_{it}}{L_{it}}\right] = c_0 + c_1 g_{it} + c_2 \ln\left[\frac{P^*_{it}}{\overline{P}_t}\right] + c_3 \ln\left[\frac{P^E_{it}}{\overline{P}_t}\right] + c_4 \ln\left[\frac{P^I_{it}}{\overline{P}_t}\right] + c_5 \ln \overline{K}_t + c_6 \ln \overline{N}_t + c_7 \ln \overline{Y}_t, \tag{9}$$

$$\ln\left[\frac{w_{Sit}}{w_{Lit}}\right] = d_0 + d_1 g_{it} + d_2 \ln\left[\frac{P^*_{it}}{\overline{P}_t}\right] + d_3 \ln\left[\frac{P^E_{it}}{\overline{P}_t}\right] + d_4 \ln\left[\frac{P^I_{it}}{\overline{P}_t}\right] + d_5 \ln \overline{K}_t + d_6 \ln \overline{N}_t + d_7 \ln \overline{Y}_t. \tag{10}$$

The import price term in equations (7) through (10) can also be replaced by the export intensity, X_{it}, and import penetration, M_{it}, if equation (6b) is selected instead of equation (6a). Note that all the estimated equations take the first difference form as explained below.

3. EMPIRICAL ANALYSIS

In this section, we discuss our empirical results. First, we describe the data used in the study, followed by a brief description of the evolution of employment and wages in Canada. The empirical results are presented last.

The Data

In this study, employment and labour compensation data are examined for a panel of 21 manufacturing industries over the 1970-1990 period. The industry classification used is the m-level input-output classification. We focus our analysis on the Canadian manufacturing sector for which data are readily available and reliable. In addition, the manufacturing sector is the most important trading sector (over 70% of total trade) in the Canadian economy. A detailed summary of sources and definitions of data used in the study can be found in Appendix A.

In our estimation model, two different measures of industry employment are used: (1) the number of workers and (2) the average number of person-hours worked per week. In addition, the average hourly labour compensation[6] is used as a measure of wages.[7] The wages variable is deflated by the implicit GDP price index for the Canadian manufacturing sector.[8] Furthermore, we have distinguished between non-production and production workers.[9] Generally speaking, non-production and production workers refer, respectively, to white collar and blue collar workers. Statistics Canada defines non-production workers as "executive, administrative and sales staff", while production workers are those engaged in "processing, assembling, storing, inspecting, handling, packing, maintenance, repair, janitorial and watchmen services and working foremen". In several studies, non-production workers are defined as skilled workers, and production workers as unskilled workers; we use the same identification here.[10]

Obtaining trade data by industry is problematic since they are usually collected and published by commodity. Imports, exports and import duty by industry were provided by Statistics Canada.[11] Unit values of imports were calculated by dividing import values by quantities; the resulting series was then used as a price index for imports. In the same way, tariff rates were calculated by dividing import duty by import values. Import prices, energy prices and material prices were deflated by the GDP implicit price index for the manufacturing sector to express them in real terms.[12]

Before proceeding with a discussion of our empirical results, it is useful to examine the evolution of employment and wages in Canada.

Descriptive Analysis

In this section, we describe the trends in employment and wages in Canada over the past twenty years.

Average Wages and Productivity

The growth of labour productivity has slowed down significantly since 1977. The average annual growth of output per hour in the Canadian commercial sector was merely 0.86 per cent over the 1977-1993 period, while the pace of real hourly consumption compensation (average hourly labour compensation deflated by the CPI) was even slower (averaging 0.21 per cent per year) as shown in Figure 1. Thus, the growth of real hourly consumption compensation failed to match productivity growth and this output-wage gap appears to indicate that income has been shifting away from labour.

However, a closer examination of the data suggests that this was not the case. Real hourly production compensation (average hourly labour compensation divided by the GDP implicit deflator) shows that real hourly production compensation grew at 1.3 per cent over the same period, thereby out-performing productivity growth (Figure 1). The reason for this faster growth is that the CPI and the GDP implicit deflator are typically constructed with different baskets of goods. Therefore, the slower real hourly consumption compensation observed is partly the result of using the CPI. When nominal compensation is deflated by the same deflator (output) used to calculate productivity, real hourly production compensation actually grew faster than productivity. Figure 2 indicates that income has not been shifting away from labour to capital since the share of labour compensation to output has not decreased over the 1968-1993 period. In fact, that share actually followed an upward trend since 1984.

The two figures indicate a growing gap between the goods we produce and the goods we consume, and the slow growth in real consumption wages might have been a simple reflection of the growing gap in production and consumption goods. Lawrence and Slaughter (1993) identify

Figure 1
Trends in Productivity and Labour Compensation, 1968-92

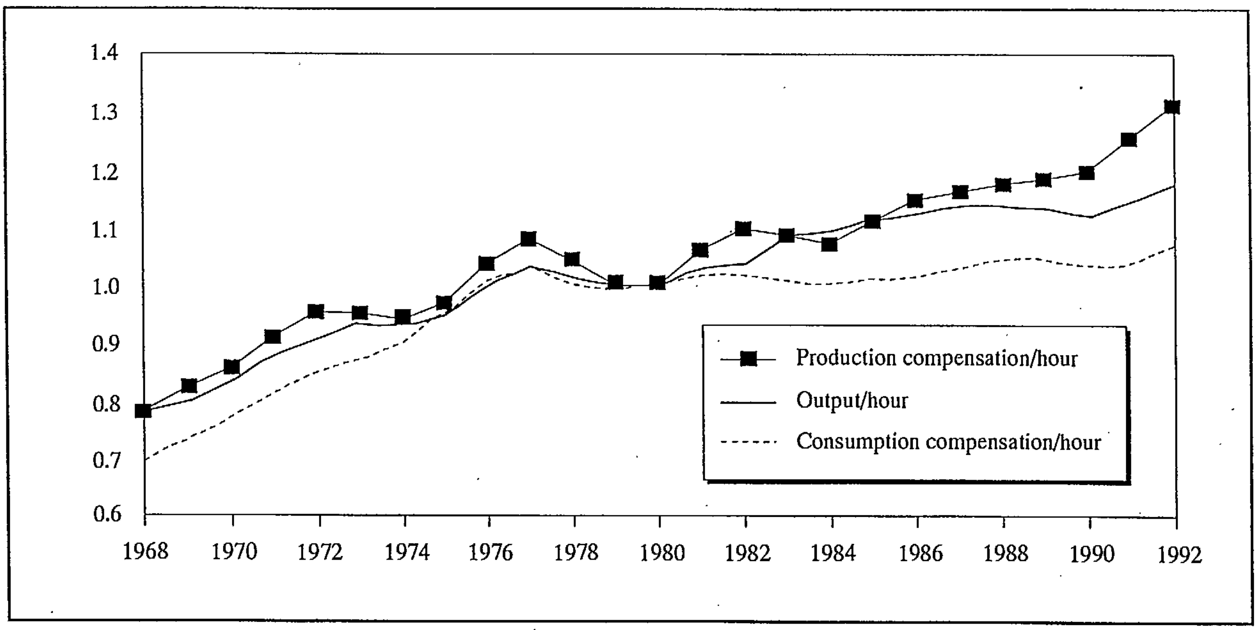
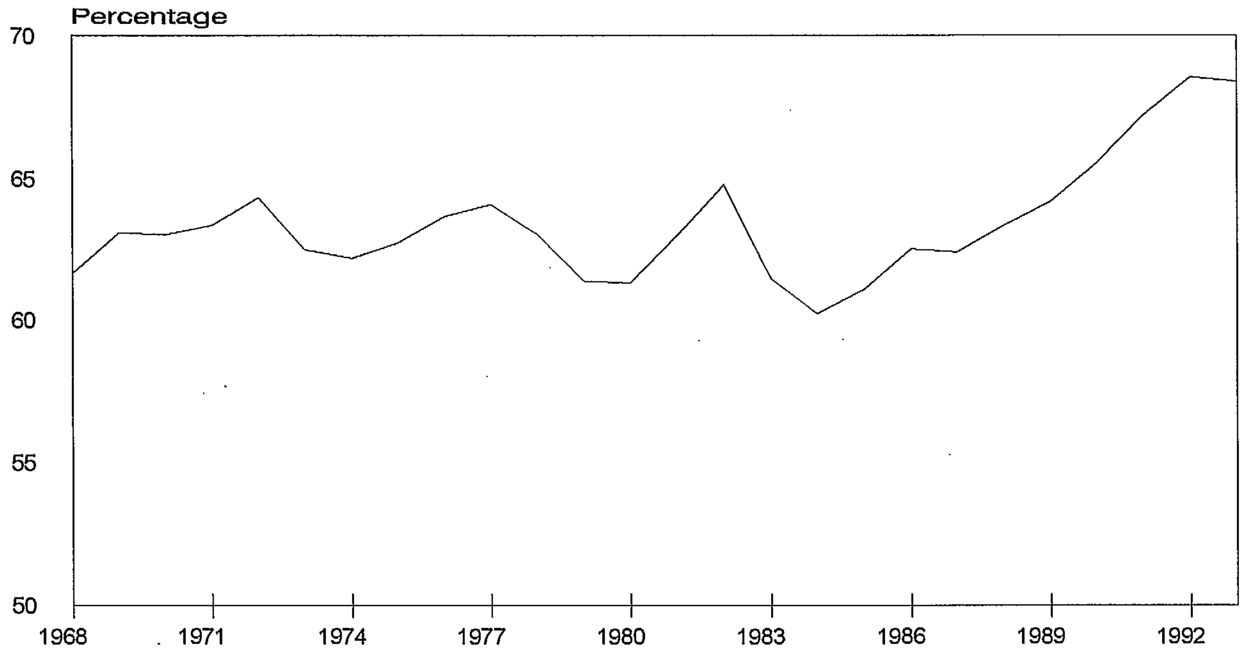


Figure 2
Compensation as a Percentage of Output, 1968-93



three potential sources of this growing gap between production and consumption goods in the U.S.: first, the prices of investment goods, which are not included in the CPI; second, the prices of imputed rent, which is excluded in the calculation of the commercial sector price index; and third, the growing importance of international trade. Any one of these factors could have been responsible for the widening gap observed between real hourly production and consumption wages in Canada. In this paper, however, we do not investigate in depth the first two factors, focusing instead on the impact of technology and imports.

Employment and Wages of Non-production and Production Workers

Table 1 lists twenty one Canadian manufacturing industries along with the employment, wages and productivity growth data used in our empirical analysis. The table shows that real hourly production compensation increased in all twenty one industries between 1970 and 1990 (reflecting productivity growth in all but two industries). Over the same period, employment increased in thirteen industries while it declined in eight. Nominal import prices increased in all industries but declined relative to the manufacturing GDP implicit price index (which increased by 6.2 percent) in most industries.

As we can see from Figure 3, the total number of person-hours worked per week and the hourly production compensation show a similar pattern in that they remained more or less steady until 1982 but increased afterwards.[13]

Table 1
Descriptive Statistics[1]

Industry	Value added,[2] 1990	ΔOutput	Employment 1990	ΔEmployment	Hourly comp.[2] 1990	ΔHourly comp.	Skilled/ unskilled emp. ratio 1990	ΔSkilled/ unskilled emp. ratio	ΔRelative wages	Δ Import price	Trade intensity 1990	ΔProductivity[3]
Food	9355.1	1.87	197.1	0.18	17.29	2.38	0.42	-1.51	0.64	5.75	0.30	0.09
Beverages	2388.4	1.07	23.8	-1.23	25.14	0.83	0.78	1.63	-0.22	3.09	0.42	0.16
Tobacco	607.1	-1.17	4.9	-3.48	34.51	3.94	0.77	3.97	-1.28	7.89	0.17	0.46
Rubber	1061.9	2.42	24.8	0.90	22.89	1.55	0.43	2.72	-2.68	4.53	0.86	0.86
Plastics	1893.7	6.79	51.9	4.87	51.92	1.49	0.29	0.72	-0.58	5.06	0.66	0.20
Leather	400.6	-1.11	16.5	-3.02	10.85	1.27	0.17	-1.98	-0.98	6.08	1.80	0.86
Textiles	2018.1	2.21	55.9	-1.11	15.34	1.81	0.29	0.35	2.86	4.40	0.75	1.45
Clothing	2493.1	1.96	103.7	-0.68	11.17	1.30	0.19	2.69	-2.30	5.28	0.61	0.96
Wood	4960.2	3.75	115.4	1.33	18.51	2.19	0.19	0.35	2.15	5.53	0.51	0.68
Furniture	1573.9	2.73	59.1	1.89	13.89	1.13	0.22	0.69	1.36	4.49	0.61	-0.17
Paper	7606.5	1.92	113.8	-0.21	25.98	2.34	0.31	0.05	0.53	4.73	0.68	-0.22
Publishing	5797.5	3.82	142.3	2.36	20.48	2.03	0.97	0.43	1.50	6.71	0.29	0.52
Primary met.	6438.0	1.11	95.2	-0.95	28.29	2.54	0.31	0.17	1.02	5.56	0.69	0.32
Fabricated met.	6483.0	1.87	166.8	0.87	17.94	1.28	0.29	-0.62	2.55	4.16	0.73	0.50
Machinery	3634.5	2.55	85.0	1.36	19.58	0.13	0.40	0.32	-2.42	1.88	2.20	0.14
Transportation	13352.5	4.75	226.8	1.92	22.73	1.88	0.30	-2.27	2.71	5.92	1.48	0.79
Electrical & elec.	8150.4	6.59	141.2	0.18	20.07	2.37	0.54	-2.07	2.46	-2.64	1.61	1.63
Non-metallic	2926.0	1.93	54.4	0.42	19.72	1.85	0.30	-1.39	2.66	6.14	0.41	0.10
Petroleum & coal	2091.7	1.70	14.0	-0.08	37.45	2.32	1.08	-0.26	-0.38	10.46	0.31	0.48
Chemicals	7646.0	3.98	92.7	0.82	23.72	1.99	0.88	-0.55	0.18	5.79	0.68	1.13
Other manufact.	2290.6	2.19	75.4	1.26	15.40	1.44	0.40	-0.89	2.00	5.35	1.62	0.27
Total manufact.	93287.7	2.86	1861.6	0.64	19.82	1.88	0.37	-0.61	1.06	3.78	0.87	0.50

1. Annual log changes from 1970 to 1990 in percentage terms.
2. Value-added in $million (1986) hourly compensation in $/hour.
3. Multifactor productivity based on gross output and hours.

Figure 3
Total Person-hours and Real Hourly Production Compensation, Manufacturing Sector, 1970-90

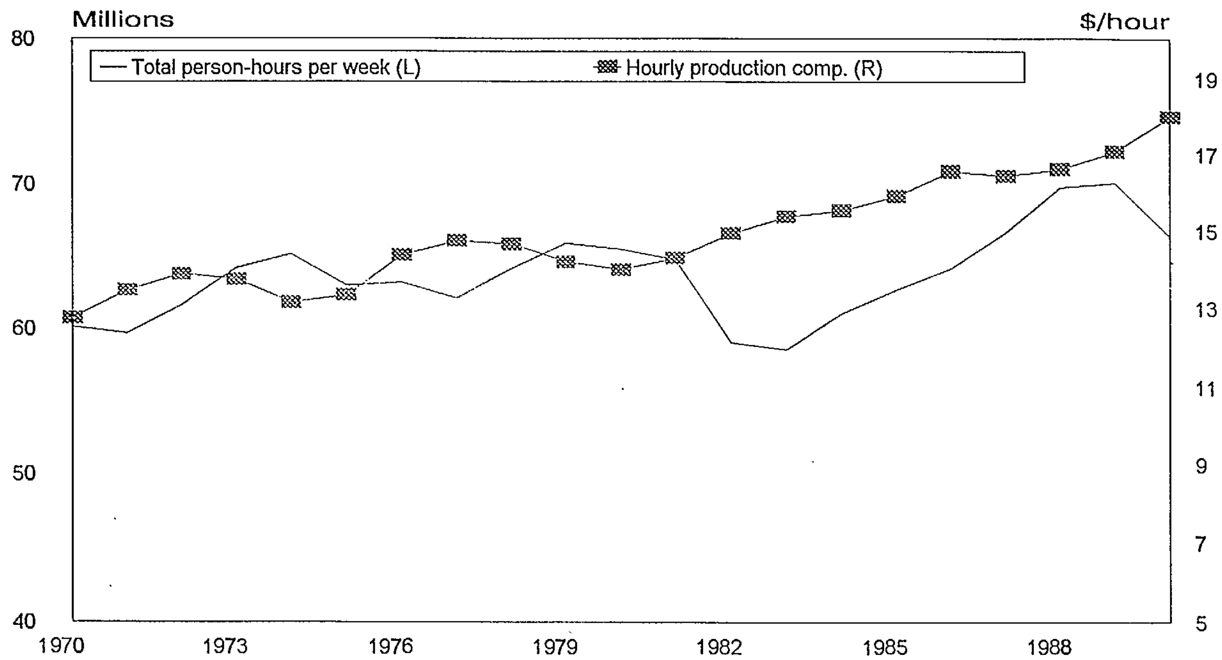
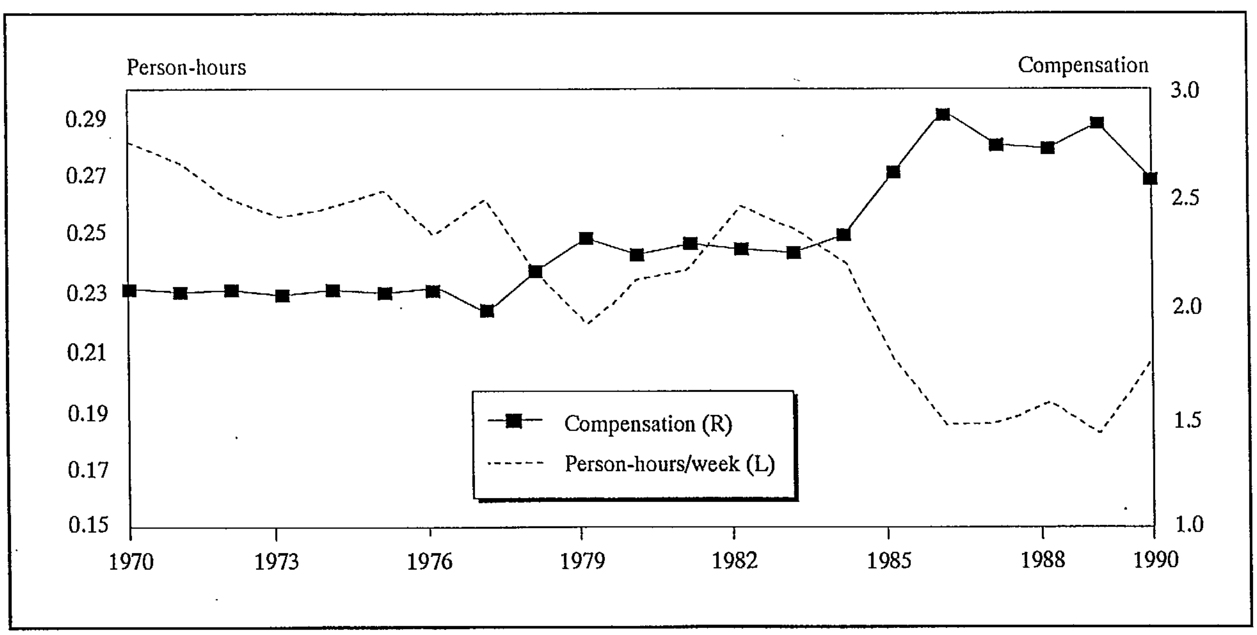


Figure 4
Ratio of Non-production to Production Workers, Manufacturing Sector, 1970-90



However, the increase in the number of person-hours worked per week and in real hourly production compensation was not equally distributed between non-production and production workers. Figure 4 shows the relative performance of person-hours worked per week and real hourly production compensation of non-production workers. The average number of hours worked per week by non-production workers decreased relative to that of production workers since 1977.[14] However, the relative real hourly production compensation of non-production workers to that of production workers increased. Figure 5 plots the annual percentage change in the relative compensation and in the relative employment of non-production workers in twenty one manufacturing industries between 1970 and 1990. In contrast to the U.S. experience[15], we can see that rising relative compensation is associated with falling relative person-hours. This suggests that the rising relative compensation of non-production workers may have prompted, in most industries, a substitution toward production workers. Thus, there is no evidence to suggest that skill-biased technical change was the dominant factor shifting relative labour demand toward a larger employment share for skilled (non-production) workers. But Figures 4 and 5 do not rule out the possibility of a trade effect on these changes during 1970-1990. For example, tariffs reductions do modify the terms of trade, usually increasing the relative wages of skilled workers in countries that export skilled labour-intensive goods, based on the Stopler-Samuelson effect. This induces a shift from unskilled workers to skilled workers.

Table 2 shows the "between-within" decomposition of the share of weekly hours of employment and total labour compensation of non-production workers and their relative hourly labour compensation rate. A shift away from non-production employment (measured in weekly hours) occurred at an annual rate of 0.10 percent over the 1970-1982 period. It accelerated to 0.37 percent over the 1982-1990 period. A similar shift away from non-production workers' labour compensation is also observed. On the other hand, non-production workers' relative hourly compensation increased in each period. But, the within-industry component dominated the between-industry component in each case. In addition, a negative sign for the within-industry component of employment and total labour compensation suggests that we cannot ignore trade as one of the possible determinants of the relative employment changes observed in Canada. [See Berman, Bound and Griliches (1994) and Berman, Machin and Bound (1995)].

Empirical Findings

There is one issue to discuss before turning to the estimation results. It concerns the nonstationarity of the variables used in this study. Unit root tests of the pooled data indicate that the null hypothesis of a unit root cannot be rejected for most variables (the variables are likely nonstationary).[16] On the other hand, unit root tests on the first differences of the variables indicate that they are stationary.[17] Hence, all equations are estimated in log differenced form.

Table 3 reports the estimation results for equations (7) and (8). Regressions were estimated using pooled cross-section time-series data under 2SLS (using instrumental variables) and GLS. We first discuss the results presented in Table 3. On the other hand, the null hypothesis of exogeneity of imports prices and aggregate employment cannot be rejected at the 5 and 10 percent level of significance based on Hausman's test. Therefore, the estimated results

Table 2
Industry Decomposition of Non-production Workers' Share

	Between	Within	Total
		(per cent)	
Weekly hours			
1970-1982	0,.050	-0.148	-0.098
1982-1990	-0.025	-0.340	-0.365
Total labour compensation			
1970-1982	0.023	-0.022	0.001
1982-1990	-0.020	-0.161	-0.181
Hourly labour compensation rate			
1970-1982	0.764	1.415	2.179
1982-1990	-2.122	5.139	3.017

shown under IV do not significantly differ from those obtained with the OLS technique. The null hypothesis of equal variance for the disturbance term across industries is rejected at the 5% level of significance. Henceforth, the discussion will be based on the GLS estimates, which allow for heteroskedascity. Both employment and real labour hourly compensation are positively related to technical progress (*g*). The estimates of the elasticity of employment and real hourly labour compensation (0.20 to 0.24) imply that a 10 percent increase in technical progress raises both employment and real hourly compensation by approximately 2 percent. This result suggests that the net effect of technical progress is to increase both employment and wages. Although the dynamic channel behind this relationship is not clear, one plausible explanation is that technical progress allow workers to earn higher wages since it raises the marginal productivity of workers. This may induce workers to increase their demand for other goods – thereby increasing overall labour demand – which may ultimately more than offset the initial decline in labour demand. The increase in labour demand would result in higher employment and wages given the upward sloping labour supply curve. On a more technical note, technological progress here can reflect both product and process innovations. Katsoulacos (1985) shows that technological change will more likely increase labour demand if the price elasticity of output supply is greater than one and the more monopolistic the market structure is.[18]

We then investigate the linkages between employment/compensation and import competition.[19] The degree of import competition is proxied by import prices.[20] Employment is positively correlated with the price of imports. Estimates of the elasticity of employment with respect to import prices are between 0.12 and 0.13. Here, import prices represent the price of imported consumer goods and the price of imported inputs. An increase in the price of imported consumer goods induces consumers to substitute domestically produced goods to imports,

Table 3
Employment and Wages Estimation Results

	Employment					
	Workers		Hours		Hourly Compensation	
	IV[1] (1)	GLS (2)	IV[1] (3)	GLS (4)	IV[1] (5)	GLS (6)
Δg	0.22	0.20	0.22	0.24	0.18	0.15
	(2.72)	(3.41)	(2.50)	(3.31)	(2.77)	(2.63)
$\Delta \ln P^*$	0.16	0.12	0.19	0.13	0.029	0.045
	(3.98)	(4.11)	(4.28)	(4.05)	(0.84)	(2.03)
$\Delta \ln P^E$	0.0029	0.00082	0.0014	0.0037	-0.0018	-0.011
	(0.27)	(0.10)	(0.12)	(0.40)	(-0.21)	(-1.60)
$\Delta \ln P^I$	-0.014	-0.013	-0.019	-0.0052	-0.096	-0.12
	(-0.44)	(-0.55)	(-0.54)	(-0.19)	(-3.58)	(-5.65)
$\Delta \ln \overline{K}$	-0.017	-0.041	0.062	0.11	0.12	0.18
	(-0.24)	(-0.75)	(0.84)	(1.76)	(2.00)	(3.97)
$\Delta \ln \overline{N}$	1.07	0.97	1.05	0.97	-0.97	-1.03
	(9.63)	(12.01)	(8.39)	(9.99)	(-10.20)	(-13.66)
$\Delta \ln \overline{Y}$	-0.13	-0.10	-0.12	-0.086	0.55	0.65
	(-2.00)	(-2.28)	(-1.63)	(1.53)	(9.91)	(14.49)
R^2	0.42	0.51	0.41	0.41	0.38	0.38
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Hausman's test	0.54		0.67		0.21	
Number of observations	420	420	420	420	420	420

1. The instrumental variables (IV) estimates control for the endogeneity of import prices. Instrumental variables for import prices include the exchange rate and the price of exports.
2. LR tests (not reported here) indicate that the OLS procedure is not appropriate since the null hypothesis of equal variance for the disturbance term among different cross-sectional units cannot be accepted at the 5% level of significance.

thereby raising employment. On the other hand, an increase in the price of imported inputs increases the cost of production, thereby decreasing employment (at least until these inputs are replaced with domestically produced ones). Our results seem to indicate that the first effect dominates the second. At the same time, the relationship between real hourly labour compensation and the price of imports is positive and the estimated elasticity of labour compensation to import prices is 0.045. Thus, an increase in the price of imports (less import competition) induces an upward shift in the derived demand for factors of production, including labour. This translates into higher employment and wages. Our estimation results suggest that adjustments take place in both employment and labour compensation.

Figure 5
Percentage Change in the Relative Compensation and Relative Person-Hours of Non-production and Production Workers, 1970-90

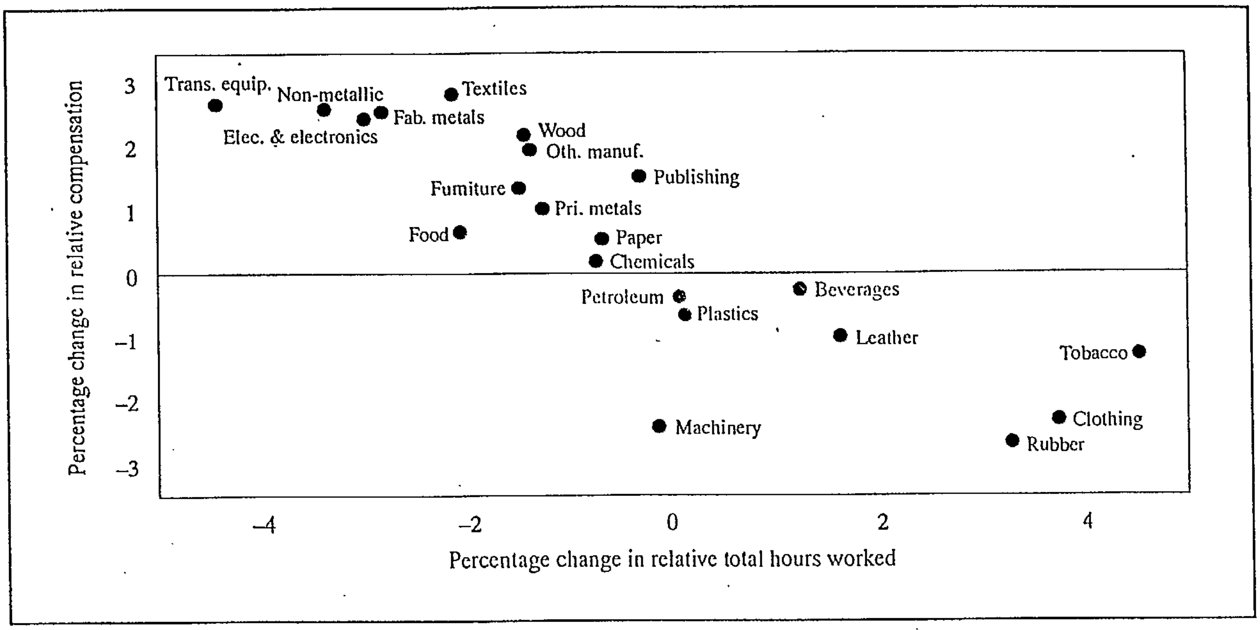


Figure 6
Percentage Change in Multifactor Productivity by Industry versus the Ratio of Non-production to Production Hours Worked, 1970-90

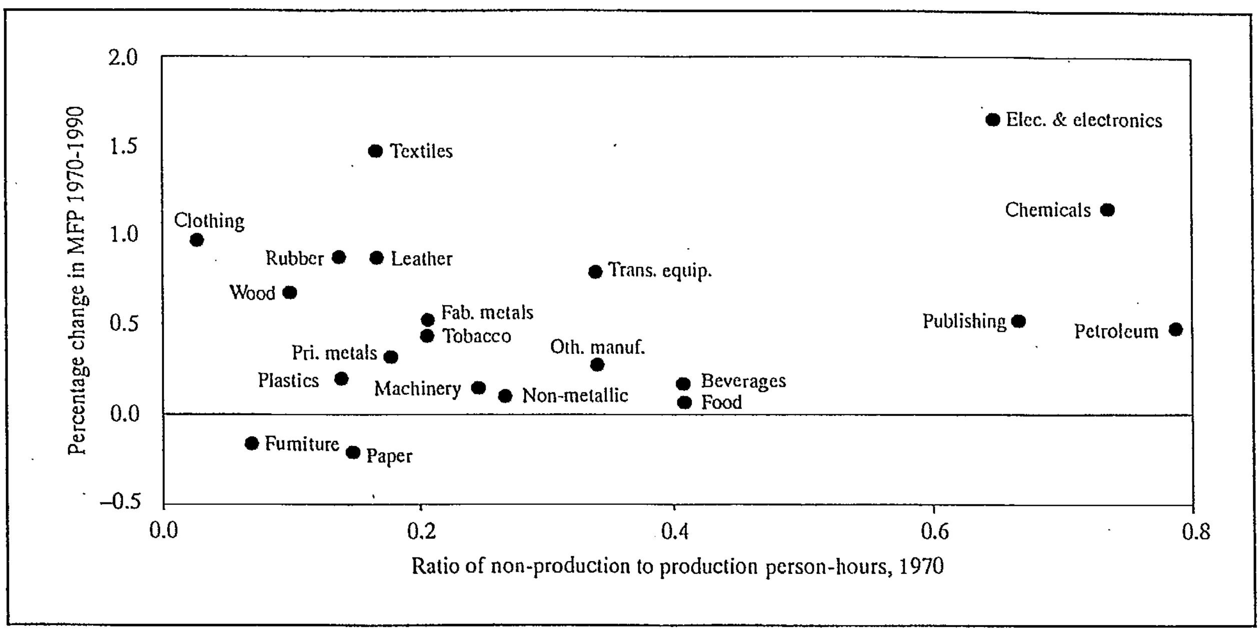


Table 4
Relative Non-production to Production Employment and Hourly Compensation Estimation Results

	Employment				Hourly Compensation	
	Workers		Hours			
	IV[1]	GLS	IV[1]	GLS	IV[1]	GLS
	(1)	(2)	(3)	(4)	(5)	(6)
Δg	-1.32	-0.51	-2.98	-1.06	1.55	0.76
	(-1.61)	(-3.80)	(-1.96)	(-3.51)	(2.67)	(3.18)
$\Delta \ln P^*$	-0.43	-0.060	-0.99	-0.24	0.33	0.25
	(-1.02)	(-1.09)	(-1.29)	(-2.40)	(1.13)	(3.39)
$\Delta \ln P^E$	0.15	0.052	0.21	0.099	-0.071	-0.089
	(1.35)	(2.99)	(1.08)	(2.85)	(-0.94)	(-3.13)
$\Delta \ln P^I$	-0.013	-0.061	0.19	0.29	-0.052	-0.29
	(-0.039)	(1.12)	(0.32)	(2.54)	(-0.23)	(-3.19)
$\Delta \ln \overline{K}$	0.90	0.26	2.33	0.67	-1.68	-0.58
	(1.24)	(2.20)	(1.86)	(2.96)	(-3.50)	(-3.15)
$\Delta \ln \overline{N}$	-1.34	-0.58	-4.09	-2.10	3.24	1.96
	(-1.17)	(-3.05)	(-1.93)	(-5.09)	(3.99)	(5.95)
$\Delta \ln \overline{Y}$	1.25	0.33	3.16	0.84	-2.06	-0.92
	(1.93)	(2.98)	(2.52)	(3.33)	(-4.30)	(-4.72)
R^2	0.011	0.12	0.11	0.13	0.081	0.12
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Hausman's test	1.17		1.13		0.042	
Number of observations	420	420	420	420	420	420

1. The instrumental variables (IV) estimates control for the endogeneity of import prices. Instrumental variables for import prices include the exchange rate and the price of exports.
2. LR tests (not reported here) indicate that the OLS procedure is not appropriate since the null hypothesis of equal variance for the disturbance term among different cross-sectional units cannot be accepted at the 5% level of significance.

Employment and real hourly compensation are not significantly related to the price of energy. At the same time, employment is not significantly related to the price of materials, whereas labour compensation is negatively correlated with it.

Three aggregate variables ($\Delta \ln \overline{K}$, $\Delta \ln \overline{N}$ and $\Delta \ln \overline{Y}$) are used to control for business cycle fluctuations. Both employment and wages are shown to be sensitive to business cycle fluctuations.

The empirical results from equations (9) and (10) about the relative changes in employment between non-production and production workers and the changes in their respective real hourly labour compensation are presented in Table 4. Again, our discussion focuses on the

GLS estimates, for the reasons discussed in the previous section. Relative employment (and person-hours) is negatively correlated, and relative hourly labour compensation is positively correlated with technical progress. One explanation is that technical progress has proceeded more rapidly in non-production-labour-intensive industries, thereby increasing the relative compensation of non-production workers. Figure 6 depicts whether technical change has been concentrated in industries that employ non-production workers more intensively. It shows that technical progress has been widespread across industries that differ in their relative employment of non-production workers. The figure does not support the view that technical progress has been concentrated in skill-intensive industries. Moreover, the relative changes in employment and real hourly labour compensation of non-production workers were driven by the within-industry component. In contrast to what Berman, Bound and Griliches (1993) and Lawrence and Slaughter (1993) have found for the U.S., there is no evidence to suggest that technical change has been biased toward non-production workers in Canada. An alternative explanation is that the labour supply of non-production workers may be less elastic than that of production workers since it takes time to acquire skills. A decline in the compensation of production worker would lead to a significant decline in their labour force participation or induces them to leave the manufacturing sector to find employment opportunities elsewhere. In any case, the net effect of technical progress[21] is likely to lower the relative employment of non-production workers and raise their relative wages if their supply is relatively inelastic compared to that of production workers.

The estimated import price elasticities are negative for relative employment (between -0.060 to -0.24) and positive for relative wages (0.25). Given that there is no evidence to suggest that the price of imports is endogenous according to Hausman's test, the price of imports appears to have reinforced the impact of technical progress on the relative working hours and wages of non-production workers.

4. CONCLUSION

The following conclusions emerge from our study of the Canadian manufacturing sector over the 1970-1990 period:

- Technical progress is positively related to employment and real hourly compensation.
- The relationship between employment and hourly labour compensation, on the one hand, and the price of imports, on the other, is positive.
- The relative employment of non-production workers is negatively related to technical progress, whereas relative real hourly compensation is positively related to technical progress.
- The relationship between the relative employment of non-production workers to the price of imports is negative. However, the relationship between the relative labour compensation of non-production workers and the price of imports is positive.

The slow growth of employment and real wages in the Canadian manufacturing sector can be attributed to slow technical progress since both employment and real hourly labour compensation are positively associated with technical progress. The net effect of technical progress appears to be an increase in both employment and wages. But technical progress also seems to be negatively associated with the relative employment of non-production workers and positively related to their relative real hourly compensation. This unequal distribution of the impact of technical progress may have nothing to do with the notion that technology is biased toward skilled workers (there is no evidence to suggest that this is the case in Canada), but may simply be a reflection of different elasticities of labour between non-production and production workers. In order to increase employment and raise wages, governments could support faster technical progress and promote its diffusion throughout the economy. At the same time, it seems necessary to encourage workers to upgrade their skills through education and training in order to reduce the possible side effect of technical progress on inequality.

An increase in import competition (a decrease in the price of imports) likely lowers employment and wages. Furthermore, imports appear to have an unequal impact on relative employment and wages – widening the gap between skilled and unskilled workers, which is a cause for legitimate concern. These results do not, however, suggest that governments should erect trade barriers to increase employment - such a move would likely invite retaliatory measures from Canada's trading partners, which would only thwart exports. To the contrary, trade should be encouraged in order to promote specialisation, which is likely to generate more employment and raise wages in the long-run. At the same time, governments should assist workers, who could be adversely affected by increased imports, acquire new skills to become employable in new or expanding sectors of the economy.

ENDNOTES

1. The use of trade volume may be defended on several grounds: first, prices of traded goods cannot be usefully compared to prices of domestic goods because of product differentiation; second, prices of traded goods may not reflect the true extent of trade due to the existence of non-tariff barriers that are difficult to quantify; third, using trade volume is appropriate under certain restrictive assumptions in theory [See Deardorff and Staiger (1988)].

2. However, reduced-form equations are not useful in understanding structural relationships. Although there are other methodologies such as the accounting approach, the input-output approach and the general equilibrium theory to study the impact of trade on employment, each has some drawbacks. See Dickens (1988) for a discussion of different methodologies.

3. Derivatives are denoted by subscripts. For example, $G_1 = \partial G / \partial P_{it}$, $G_2 = \partial G / \partial Y_{it}$ and $G_3^j = \partial G_3^j / \partial v_{it}^j$, where superscript *j* refers to *j*th input.

4. Henceforth, a bar denotes an aggregate variable.

5. Note that we do not distinguish between skilled and unskilled workers at this point.

6. Includes supplementary labour income.

7. Alternatively, labour compensation per worker is also used. This alternative measurement does not change the results significantly.

8. The aggregate CPI is also used to deflate the wages variable. But qualitative results do not change significantly.

9. From 1970 on, Statistics Canada relied on "long form", "short form" and administrative files to collect information on manufacturing industries. The detailed "long form", which tracks the number of production and non-production workers, has been used only for large establishments. The remaining smaller establishments used a "short form" survey or administrative files, in which workers are labelled only as production workers to complement the "long form" survey. As a result, raw data overstate the number of production workers. Following Betts (1994), the proportion of manufacturer's shipments accounted for by firms filling out the long form was used to adjust the data. See Betts (1994) for details.

10. Berman, Bound and Griliches (1994) and Sachs and Shatz (1994) report that the percentage of non-production workers tracks well the level of skills in the U.S. Since similar definitions are used in defining non-production and production workers in Canada, we also resort to this measure to distinguish between skilled and unskilled workers.

11. The concordance approach was used to obtain trade data by industry. The tables in the commodity space were pre-multiplied by the market-share matrix "D" to normalise the commodities by industries appearing in the output matrix. This methodology only captures imports that are in competition with domestic goods. Therefore, the imports that do not have counterparts in Canada are not counted under this approach.

12. A change in the relative price of imports to the aggregate price of domestic goods (not relative to the domestic price of good *i* which is endogenous) initiates a resource reallocation process. Of course, a change in the domestic price of good *i* relative to both import prices and the aggregate price of domestic goods could trigger the same process, but it would not be correct to attribute the resulting shift in resources to imports.

13. Similarly for employment and real compensation per worker.

14. Twelve OECD countries and most developing countries examined by Berman, Machin and Bound (1995) show increases in the proportion of non-production workers' employment during the 1970s and 1980s.

15. Lawrence and Slaughter (1993) show that an increase in the relative wages of non-production workers is associated with an increase in their relative employment in the U.S.

16. The results are presented in Table C1 of Appendix C. A preliminary investigation indicates that there is no evidence of cointegration of these variables. Hence, regressions of the first difference form appear to be appropriate.

17. The results are presented in Table C2 of Appendix C.

18. This is not inconsistent with the Hicksian definition of labour-saving technology since it refers to the impact of technology on labour demand when holding the wage-rental ratio constant.

19. We implicitly ignore the effect of the factor content of trade on employment. The factor content of trade that accompany changes in employment will have little effect on relative wages unless output prices also change.

20. Inclusive of tariff rates. Using the price of imports implicitly assumes that the foreign supply curve is perfectly elastic. It is, however, inappropriate to identify import competition with the volume of imports since it is an endogenous variable influenced by conditions in both the domestic and foreign markets. Furthermore, Bhagwati and Dehejia (1994) show that a country can run a trade deficit without changing real wages. In any case, the empirical results using export intensity and import penetration [as noted in Baldwin (1994)] in lieu of import prices are presented in Appendix D. The results are not qualitatively different from those presented in Tables 3 and 4.

21. Neutral or biased toward the use of non-production workers but not to the extent that it overturns the observed results.

APPENDIX A
DEFINITIONS AND SOURCES OF DATA

List of Variables and Parameters

Variable	Definition	Source
CPI	Consumer price index	1970-1992 CANSIM (P484549)
POUT	GDP implicit price deflator	1970-1992 CANSIM (D20000, D20463)
PFX	Canadian dollar per U.S. dollar	1970-1992 CANSIM (B3400)
P^{E^*}	Energy price index in U.S. dollars	1970-1992 Bank of Canada
P^{I^*}	Industrial materials price index in U.S. dollars	1970-1992 Bank of Canada
P^E	Energy price	1970-1992 $= PFX*P^{E^*}$ 1971-1992 Energy Statistics Handbook Statistics Canada
P^I	Industrial materials price	1970-1992 $= PFX*P^{I^*}$
$\overline{Y}$	Real gross output at factor cost in the manufacturing sector	1970-1992 CANSIM (I34005)
$\overline{YN}$	Nominal gross output at factor cost in the manufacturing sector	1970-1992 CANSIM (I28005)
$\overline{P}$	Price of output in the manufacturing sector	1970-1992 $= \overline{YN}/\overline{Y}$
$\overline{K}$	Net capital stock based on geometric depreciation in the manufacturing sector	1970-1992 CANSIM (I816144)
$\overline{Nh}$	Total number of person-hours paid in the manufacturing sector	1970-1992 CANSIM (I190306)

Nh_i	Total number of person-hours paid	1970-1992 CANSIM (I190307-I190327) Statistics Canada, Catalogue no. 15-204
Lh_i	Production workers' person-hours paid	1970-1980 CANSIM (D900750, D901020, D901317, D901641, D901992, D902262, D902613, D902991, D903369, D903720, D904098, D904422, D904800, D905151, D905502, D905826, D906204, D906555, D906933, D907284, D900372) 1981-1986, 1988-1992 CANSIM (D662300, D662685, D662883, D663059, D663246, D663455, D663653, D663851, D664104, D664456, D664764, D665006, D665303, D665534, D665798, D666216, D666447, D666799, D667162, D667492, D667679, D667976, D662146) 1987 $= (Lh_{i,1988} + Lh_{i,1986})/2$ Statistics Canada, Catalogue no. 31-203
Sh_i	Non-production workers' person-hours paid	1970-1992 $= Nh_i - Lh_i$
$\overline{N}$	Total number of person-hours worked per week in the manufacturing sector	1970-1992 $= \overline{Nh}/52$
N_i	Total number of person-hours worked per week	1970-1992 $= Nh_i/52$
$\overline{L}$	Production workers' person-hours worked per week in the manufacturing sector	1971-1992 $= \overline{Lh}/52$
L_i	Production workers' person-hours worked per week	1971-1992 $= Lh_i/52$
$\overline{S}$	Non-production workers' person-hours worked per week in the manufacturing sector	1971-1992 $= \overline{Sh}/52$
S_i	Non-production workers' person-hours worked per week	1971-1992 $= Sh_i/52$

W_i^N	Total salaries and wages	1971-1986 CANSIM (D900755, D901025, D901322, D901646, D901997, D902267, D902618, D902996, D903374, D903725, D904103, D904427, D904805, D905156, D905507, D905831, D906209, D906560, D906938, D907289, D900377) 1988-1992 CANSIM (D662306, D662391, D662889, D663065, D663252, D663461, D663659, D663857, D664110, D664462, D664770, D665012, D665309, D665540, D665804, D666222, D666453, D666805, D667168, D667498, D667685, D667982, D662152) 1987 $= N_i - L_i$ Statistics Canada, Catalogue no. 31-203
W_i^L	Production workers' wages	1971-1982 CANSIM (D900748, D901018, D901315, D901639, D901990, D902260, D902611, D902289, D903367, D903718, D904096, D904420, D904798, D905149, D905500, D905824, D906202, D906553, D906931, D907282, D900370) 1982-1986, 1988-1992 CANSIM (D662299, D662684, D662882, D663058, D663245, D663454, D663652, D663850, D664103, D664455, D664763, D665005, D665302, D665533, D665797, D666215, D666446, D666798, D667161, D667491, D667678, D667975, D662145) 1987 Statistics Canada, Catalogue no. 31-203
W_i^S	Non-production workers' wages	1971-1992 $= WT_i - WL_i$
SLI_i	Supplementary labour income	CANSIM (I49808-I49828)
w_i	Average worker's real production hourly wages	1971-1992 $= [(WN_i + SLI_i)/Nh_i]/POUT$

w_i^S	Non-production workers' real production hourly wages	1971-1992 $=\{[WS_i + (WS_i/WN_i)*SLI_i]/Sh_i\}/POUT$
w_i^L	Production workers' average real production hourly wages	1971-1992 $=\{[WL_i + (WL_i/WN_i)*SLI_i]/Lh_i\}/POUT$
G_i	Gross-output measure of multifactor productivity based on the number of person hours	1971-1992 CANSIM (I700406-I700410, I700413-I700425, I700436-I700439) Statistics Canada, Catalogue no. 15-204E
Y_i	Gross output for industry *i*	Statistics Canada
EX_i	Nominal value of exports	Statistics Canada
REX_i	Real value of exports	Statistics Canada
IM_i	Nominal value of imports	Statistics Canada
RIM_i	Real value of imports	Statistics Canada
P_i^X	Export price for industry *i*	$= EX_i/REX_i$
P_i^M	Import price for industry *i*	$= IM_i/RIM_i$
DU_i	Import duties for industry *i*	Statistics Canada
τ_j	Tariff rate for industry *i*	$= DU_i/IM_i$
P_i^*	Import price including tariff	$= P_i^M(1+\tau_i)$
X_i	Export intensity	$= REX_i/Y_i$
M_i	Import penetration	$= RIM_i/(Y_i - RX_i + RIM_i)$

APPENDIX B
DECOMPOSITION EQUATION

In this section, we use the methodology introduced by Berman, Bound and Griliches (1994) and Berman, Machin and Bound (1995) to decompose a change in the share of non-production workers into changes in shares between industries and changes within each industry. For example, if N is the share of non-production workers in the economy, the following equation can be used to decompose a change in the share on non-production employment (or wages):

$$\Delta N = \sum_i \Delta S_i \overline{N}_i + \sum_i \Delta N_i \overline{S}_i, \text{ where } i = 1,\ldots,n \text{ and} \tag{B1}$$

N denotes the share of non-production employment and N_i, the share of non-production employment in industry *i*; S_i is the share of employment in industry *i* and a bar over a term implies a mean over time. Therefore, the first term indicates the "between" industry component and the second term measures the change in the share of non-production workers attributable to changes in the share of non-production employment "within" each industry.

APPENDIX C
UNIT ROOT TESTS

Table C1. Pooled Unit-Root Tests

	No-trend		With-trend		
	τ-test	zero-drift	τ-test	zero drift	non-zero drift
$\ln\overline{N}$	-0.27	0.51	-0.88	1.41	1.64
$\ln\overline{S}$	-0.21	0.52	-0.83	1.40	1.60
$\ln\overline{L}$	-0.31	0.51	-0.92	1.42	1.66
$\ln\overline{Nh}$	-0.24	0.52	-0.85	1.40	1.61
$\ln\overline{Sh}$	-0.22	0.53	-0.83	1.38	1.56
$\ln\overline{Lh}$	-0.26	0.51	-0.87	1.41	1.63
$\ln\overline{K}$	-0.33	0.58	-0.26	1.33	1.48
$\ln\overline{Y}$	-0.69	0.62	-1.21	1.48	1.84
$\ln N$	-1.08	1.10	-0.96	1.15	1.20
$\ln S$	-2.00	2.34	-1.95	1.56	2.00
$\ln L$	-0.76	0.85	-0.68	1.07	1.05
$\ln SL$	-0.66	0.63	-1.40	1.75	2.22
$\ln Nh$	-1.87	2.04	-1.85	1.47	1.89
$\ln Sh$	-1.35	1.39	-1.34	1.15	1.25
$\ln Lh$	-1.59	1.60	-1.79	1.59	2.06
$\ln SLh$	-3.30	5.46	-3.68	4.61	6.91
$\ln GN$	-1.20	1.06	-1.73	1.80	2.36
$\ln GH$	-1.23	1.09	-1.74	1.82	2.39
$\ln W^{NP}$	-0.49	0.78	-0.14	1.15	1.06
$\ln W^{SP}$	-0.048	0.61	0.10	1.22	1.22
$\ln W^{LP}$	-3.04	4.64	-3.10	3.21	4.81
$\ln W^{SLP}$	-2.92	4.28	-3.19	3.50	5.23
$\ln W^{NC}$	-0.44	0.73	-0.084	1.14	1.08
$\ln W^{SC}$	-1.20	1.11	-1.35	1.64	2.08
$\ln W^{LC}$	-3.11	4.85	-3.12	3.25	4.87
$\ln W^{SLC}$	-0.50	0.56	-0.97	1.34	1.56
$\ln Wh^{NP}$	-0.86	0.82	-1.48	1.54	1.86
$\ln Wh^{SP}$	-1.78	1.94	-2.07	1.92	2.53
$\ln Wh^{LP}$	-0.37	0.57	-0.98	1.38	1.56
$\ln Wh^{SLP}$	-0.91	0.80	-1.36	1.45	1.78
$\ln Wh^{NC}$	-0.82	0.79	-1.43	1.52	1.82
$\ln Wh^{SC}$	-1.59	1.64	-1.89	1.74	2.24
$\ln Wh^{LC}$	-0.43	0.58	-1.04	1.39	1.59
$\ln Wh^{SLC}$	-1.11	1.00	-1.30	1.23	1.46
$\ln P^{E}$	7.90	31.83	7.68	21.27	31.28
$\ln P^{*}$	-0.23	0.52	-0.59	1.34	1.52
$\ln P^{I}$	-4.84	11.73	-4.96	8.22	12.29
$\ln P$	-4.21	8.86	-4.22	5.97	8.96
$\ln P^{FX}$	-8.98	40.88	-8.99	28.38	42.04
$\ln X$	-2.57	3.48	-3.08	3.38	4.89
$\ln M$	-2.32	2.95	-2.72	2.66	3.74

1. Critical values are -2.57, 3.78, -3.13, 4.03 and 5.34 at the 10 % level, respectively.

Table C2. Pooled Unit-Root Tests (Log Differences)

	No-trend		With-trend		
	τ-test	zero-drift	τ-test	zero drift	non-zero drift
$\Delta\ln\overline{N}$	-6.44	20.79	-6.64	14.71	22.07
$\Delta\ln\overline{S}$	-6.73	22.64	-6.91	15.92	23.88
$\Delta\ln\overline{L}$	-2.58	4.23	2.22	3.79	4.78
$\Delta\ln\overline{Nh}$	-6.18	19.11	-6.42	13.74	20.59
$\Delta\ln\overline{Sh}$	-6.41	20.58	-6.61	14.58	21.88
$\Delta\ln\overline{Lh}$	-6.52	21.29	-6.73	15.11	22.65
$\Delta\ln\overline{K}$	3.07	5.88	2.47	4.91	6.19
$\Delta\ln\overline{Y}$	2.83	5.06	2.25	4.34	5.43
$\Delta\ln N$	-6.40	20.48	-6.44	13.84	20.76
$\Delta\ln S$	-4.81	11.55	-4.82	7.75	11.63
$\Delta\ln L$	-6.77	22.88	-6.78	15.35	23.02
$\Delta\ln SL$	-5.72	16.35	-5.75	11.00	16.51
$\Delta\ln Nh$	-6.16	18.98	-6.28	13.16	19.73
$\Delta\ln Sh$	-8.70	16.26	-5.76	11.08	16.62
$\Delta\ln Lh$	-6.31	19.88	-6.42	13.71	20.59
$\Delta\ln SLh$	-6.13	18.80	-6.16	12.66	18.99
$\Delta\ln GN$	-6.17	19.04	-6.38	13.58	20.37
$\Delta\ln GH$	-5.87	17.21	-6.10	12.41	18.62
$\Delta\ln W^{NP}$	-2.04	2.41	-2.41	2.32	3.16
$\Delta\ln W^{SP}$	-2.40	3.14	-2.78	2.91	4.09
$\Delta\ln W^{LP}$	-2.33	3.00	-2.70	2.72	3.81
$\Delta\ln W^{SLP}$	-6.65	22.09	-6.66	14.78	22.17
$\Delta\ln W^{NC}$	-2.65	3.75	-2.98	3.22	4.59
$\Delta\ln W^{SC}$	-3.44	6.04	-3.79	4.92	7.25
$\Delta\ln W^{LC}$	-2.94	4.49	-3.28	3.75	5.46
$\Delta\ln W^{SLC}$	-6.16	19.00	-6.18	12.74	19.11
$\Delta\ln Wh^{NP}$	-5.31	14.11	-5.32	9.51	14.25
$\Delta\ln Wh^{SP}$	-6.13	18.77	-6.15	12.64	18.95
$\Delta\ln Wh^{LP}$	-5.37	14.45	-5.41	9.83	14.74
$\Delta\ln Wh^{SLP}$	-6.57	21.59	-6.60	14.53	21.80
$\Delta\ln Wh^{NC}$	-6.50	21.13	-6.49	14.06	21.08
$\Delta\ln Wh^{SC}$	-6.14	18.83	-6.17	12.68	19.02
$\Delta\ln Wh^{LC}$	-5.38	14.49	-5.41	9.84	14.76
$\Delta\ln Wh^{SLC}$	-5.72	16.39	-5.78	11.15	16.72
$\Delta\ln P^{E}$	-7.47	27.87	-7.45	18.55	27.81
$\Delta\ln P^{*}$	-13.68	93.64	-13.67	62.28	93.41
$\Delta\ln P^{I}$	-6.26	19.62	-6.25	13.05	19.56
$\Delta\ln P$	-6.67	22.27	-6.66	14.81	22.20
$\Delta\ln P^{FX}$	-1.54	1.44	-1.88	1.79	2.43
$\Delta\ln X$	-6.15	18.91	-6.16	12.68	19.02
$\Delta\ln M$	-4.71	11.11	-4.71	7.41	11.11

1. Critical values are -2.57, 3.78, -3.13, 4.03 and 5.34 at the 10 % level, respectively.

APPENDIX D
EMPIRICAL RESULTS ON EXPORT INTENSITY AND IMPORT PENETRATION

In this section, we briefly discuss the empirical results presented in Tables D1 and D2. First, the null hypothesis of exogeneity of export intensity and import penetration is rejected. This is not surprising since trade flows are an endogenous response to changes in prices of tradables. Furthermore, the null hypothesis of homoskedasticity is also rejected at the 5% level of significance. Therefore, the discussion will be based on the GLS-IV estimates, which allow for endogeneity of export intensity and import penetration as well as heteroskedasticity.

The estimation results presented in Table D1 are not significantly different from those shown in Table 3 with respect to the impact of technological progress on employment and labour compensation. Both employment and real hourly labour compensation are positively related to technological progress.

Both employment and real hourly labour compensation are not significantly related to export intensity except in regression (2). Although an increase in export intensity may induce faster employment growth, it may also give rise to outsourcing, thereby offsetting the positive impact of exports. On the other hand, both employment and real hourly labour compensation are negatively related to import penetration. This may be due to the fact that a higher level of imports may induce a decline in product demand and, consequently, in the demand for labour.

Table D2 shows our empirical results for the relationship between changes in relative employment between non-production and production workers and their respective real hourly labour compensation. Again, the impact of technological progress on relative employment and real hourly labour compensation does not differ significantly from that presented in Table 4. But the relationships between relative employment and hourly labour compensation, on the one hand, and the trade variables on the other, are weak.

Table D1. Employment and Hourly Compensation Estimation Results

	Employment				Hourly compensation	
	Workers		Hours			
	GLS (1)	GLS-IV[1] (2)	GLS (3)	GLS-IV[1] (4)	GLS (5)	GLS-IV[1] (6)
Δg	0.17	0.16	0.22	0.17	0.12	0.10
	(2.96)	(2.36)	(2.95)	(2.09)	(2.95)	(1.64)
$\Delta \ln X$	-0.0051	-0.023	0.0019	-0.011	0.0091	-0.0071
	(-0.45)	(-2.67)	(0.15)	(-0.98)	(0.94)	(-0.68)
$\Delta \ln M$	0.0026	-0.011	-0.029	-0.014	-0.022	-0.0095
	(0.15)	(-2.09)	(-1.48)	(-2.34)	(-1.54)	(-1.92)
$\Delta \ln P^E$	0.0048	0.0053	0.010	0.0098	-0.0076	-0.0084
	(0.62)	(0.69)	(1.19)	(1.08)	(-1.12)	(-1.23)
$\Delta \ln P^I$	-0.015	0.013	0.00049	0.0012	-0.12	-0.12
	(-0.63)	(0.51)	(0.018)	(0.040)	(-5.69)	(-4.96)
$\Delta \ln \overline{K}$	0.037	0.050	0.11	0.11	0.18	0.18
	(0.67)	(0.89)	(1.86)	(1.69)	(3.95)	(3.84)
$\Delta \ln \overline{N}$	0.95	0.77	0.89	0.83	-1.06	-1.11
	(11.55)	(7.80)	(9.31)	(7.40)	(-14.10)	(-12.62)
$\Delta \ln \overline{Y}$	-0.074	0.77	-0.035	0.038	0.68	0.72
	(-1.59)	(0.13)	(-0.62)	(0.55)	(15.32)	(13.80)
R^2	0.50	0.51	0.48	0.48	0.52	0.53
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Hausman's test	14.14		6.3		14.40	
Number of observations	420	420	420	420	420	420

1. The instrumental variables (IV) estimates control for the endogeneity of export intensity and import penetration. Instrumental variables for export intensity and import penetration are the exchange rate, the price of exports and the price of imports.
2. LR tests (not reported here) indicate that the OLS procedure is not appropriate since the null hypothesis of equal variance for the disturbance term among different cross-sectional units cannot be accepted at the 5% level of significance.

Table D2. Relative Non-production to Production Employment and Hourly Compensation Estimation Results

	Employment					
	Workers		Hours		Hourly Compensation	
	GLS (1)	GLS-IV[1] (2)	GLS (3)	GLS-IV[1] (4)	GLS (5)	GLS-IV[1] (6)
$\Delta \ln G$	-0.53	-0.47	-0.91	-0.67	0.58	0.36
	(-3.91)	(-3.32)	(-2.95)	(-2.12)	(2.32)	(1.39)
$\Delta \ln X$	-0.031	-0.018	-0.026	-0.061	-0.011	0.049
	(-1.16)	(-0.84)	(-0.51)	(-1.16)	(-0.33)	(1.04)
$\Delta \ln M$	-0.0039	-0.0039	0.0093	0.035	-0.049	-0.058
	(-0.11)	(-0.31)	(0.13)	(1.48)	(-0.97)	(-2.82)
$\Delta \ln P^E$	0.049	0.046	0.083	0.075	–0.064	-0.058
	(2.96)	(2.77)	(2.33)	(2.15)	(-2.23)	(-2.06)
$\Delta \ln P^I$	-0.075	-0.033	0.23	0.35	-0.25	-0.34
	(-1.32)	(-0.54)	(1.87)	(2.85)	(-2.67)	(-3.47)
$\Delta \ln \overline{K}$	0.22	0.26	0.62	0.46	-0.57	-0.39
	(1.79)	(2.08)	(2.57)	(1.81)	(-3.03)	(-1.94)
$\Delta \ln \overline{N}$	-0.49	-0.70	-1.77	-2.01	1.82	1.84
	(-2.53)	(-2.96)	(-4.08)	(-4.43)	(5.47)	(5.08)
$\Delta \ln \overline{Y}$	0.27	0.33	0.61	0.48	-0.77	-0.55
	(2.43)	(2.46)	(2.39)	(1.76)	(-3.94)	(-2.52)
R^2	0.13	0.12	0.11	0.13	0.10	0.13
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Hausman's test	121		111		66	
Number of observations	420	420	420	420	420	420

1. The instrumental variables (IV) estimates control for the endogeneity of export intensity and import penetration. Instrumental variables for export intensity and import penetration are the exchange rate, the price of exports and the price of imports.
2. LR tests (not reported here) indicate that the OLS procedure is not appropriate since the null hypothesis of equal variance for the disturbance term among different cross-sectional units cannot be accepted at the 5% level of significance.

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