
Gilles Grenier
Department of Economics
University of Ottawa
Ottawa, Canada
Email Address: gilles.grenier@uottawa.ca

Akbar Tavakoli
Department of Industrial Engineering
Isfahan University of Technology
Isfahan, Iran
Email Address: atavakoli@cc.iut.ac.ir

Revised, April 2008

Abstract:
The economic position of low-skilled workers relative to high-skilled workers has worsened in many industrialised nations since the late 1970s. This paper compares Canada and the United States in terms of the evolution of the relative wages of production and non-production workers in the manufacturing sector between 1970 and 2001. The independent variables of the analysis include R&D expenditures, union density, imports from developing countries, immigration, capital labour ratio, and number of workers in each group. The results show that the wage ratio is affected by similar economic globalisation variables in each country. However, between the two nations, other than technological changes, the overall effect of globalisation is more pronounced in Canada. Among economic globalisation variables such as technological changes and imports from developing countries, the latter has less harmful effect on low skilled workers in the U.S. Among the other variables, the wage gap is more affected by union density in Canada. The impact of immigration on the wage gap is low in both countries.

I. Introduction:

It is well known that the economic position of low-skilled workers relative to high-skilled workers has worsened in many industrialised nations since the late 1970s. The possible causes for that deterioration include international trade liberalisation, technical change, labour migration and changes in labour market institutions such as unions. The losses of the least-qualified section of the labour force took the form of a decline in their wages relative to the most skilled, or in their relative likelihood of being in work, or both (Greenaway and Nelson, 2001, P.2). The largest increases in inequality were mainly observed in countries with decentralised labour markets, such as the U.K. and the U.S., whereas European countries with centralised wage-setting institutions, such as Germany, France and Sweden, either escaped the trend toward greater inequality or experienced relatively mild increases (Gottschalk, 1997, P.34).

The purpose of this study is to examine and compare the evolution of inequality in two specific countries, Canada and the U.S., by looking at the wages of production and non-production workers in the manufacturing sector from the early 1970s to the early 2000s. Canada and the U.S. share a common border and have highly integrated economies, especially in the manufacturing sector, but they also have different institutions, with more government intervention and social protection in Canada. As emphasised by Card and
Freeman, “the mixture of similarities and differences in institutions and policies between Canada and the United States provides a series of ‘experiments’ for studying how policies and institutional developments affect the labor market and the economy” (Card and Freeman, 1994, P.190).

A summary of the empirical literature is presented in section II. The economic patterns of the main variables are analysed in section III. In section IV, the model specification and the estimation results are presented. The major conclusions are summarised in the last section.

II. Review of Empirical Findings

A number of empirical studies have shown that economic globalisation has affected workers’ positions in industrialised nations. International trade liberalisation raises the burden of adjustment on high-cost environments. Lower labour costs in developing countries (DCs) are a legitimate source of comparative advantage for developed nations to buy more labour-intensive cheap products from these countries. It is the unskilled workers in developed nations who are the most vulnerable to the expansion of international trade. Increasing economic competition, therefore, leads to downward pressures on labour standards (Campbell, 1994; Richardson, 1995; Lee, 1997; Rodrik, 1997; Wood, 1998; Freeman, 1998; Leamer, 2000). There exist no jurisdictions comparable to national states to protect workers against those pressures (Ross, 2000).

There have been controversies over the importance of the trade liberalisation effects on wage inequality. To measure the effect of trade on the labour market, the ratio of imports from DCs to output is generally applied. The opponents of the effect of trade criticise this criterion, arguing that the value of this ratio is too small to explain the large changes in relative wages that have been observed (Lawrence, 1994; Topel, 1997; Johnson, 1997; OECD, 1998; Ghose, 2000; Krugman, 2000).

It is thus claimed that the effect of skilled-biased technological changes (SBTC) is more important. SBTC shifts labour demand and increases wage differentials between skilled and unskilled workers by raising the marginal product of skilled workers. Most studies that have examined the causes of demand shifts conclude that the SBTC accounts for a large share of the rise in wage inequality (Krueger, 1993; Berman et al., 1994; Johnson, 1997; Slaughter, 1998; Machin and Van Reenen, 1998; Murphy et al., 1998; Rogowsky et al., 2001).

There are also arguments in favour of both the effects of trade and technical changes on wage inequality (Brauer and Hickok, 1995; Baldwin and Rafiquzzaman, 1998; Feenstra and Hanson, 1999; Driffield and Taylor, 2000). However, the main finding is that the effect of technical change appears to outweigh the effect of trade. Some also contend that there are effects of both trade and immigration (Borjas et al., 1992; Cline, 1997; Freeman, 1998), but other studies cast doubt on the effect of immigration and find that it has a negligible effect on the wages of unskilled workers (Friedberg and Hunt, 1995; Topel, 1997).
The effect of union on wage inequality is also an issue. It has been shown that, as the collective bargaining power of union deteriorated, the unskilled workers’ economic position also declined (DiNardo and Lemieux, 1997; Grenier and Tavakoli, 2006).

Table 1 summarises empirical studies on relative wages in the U.S. and in Canada. Most studies focus on the effects of technical changes and international trade, while just a few look at unions and immigration. The data and models vary. The majority of the studies are based on regression analysis, but the method of factor content is also used.\(^1\)

The empirical studies confirm the positive role of trade in widening wage inequality in the U.S. (Borjas and Ramey, 1994; Sachs and Shatz, 1994 and 1998; Wood, 1995 and 1998; Slaughter and Swagel, 1997; Feenstra and Hanson, 2001). The effect is found to be between small and a moderate (Richardson, 1995; Cline, 1997; Baldwin and Cain, 1997; Slaughter, 1998). When both trade and immigration are accounted for, the effect of the former is found to dominate the latter (Borjas et al., 1992, 1996, and 1997; Thygesen et al., 1996; Cline, 1997; Freeman, 1998). The weight of evidence, however, is that international trade had a smaller role in shifting labour demand than technical changes (Berman et al., 1994; Machin and Van Reenen, 1998; Allen, 2001).

In the Canadian manufacturing industries, import competition has been found to have a negative effect on wage differentials (Grey, 1999). It was observed that, “the real wages of both more and less educated workers go up in response to increased trade liberalisation, but the more educated benefit relatively more than their counterparts” (Zakhilwal, 2000, P.7). Some studies find a positive role for only SBTC in widening the wage gap (Betts, 1997). Comparing trade and SBTC effects, it is argued that the types of technologies have also contributed to the wage gap (Baldwin and Rafiquzzaman, 1998). Some studies also stress the importance of deunionization on wage inequality (Lemieux, 1998; DiNardo and Lemieux, 1997; Grenier and Tavakoli, 2006).

When the two countries are compared, it is found that wage inequality followed different patterns (Freeman and Needels, 1993; Richardson, 1997; Murphy et al., 1998; Burbidge et al., 2002). During the 1980s and 1990s, the ratio of skilled to unskilled workers wages increased more in the U.S. than in Canada (Richardson, 1997; Murphy et al., 1998; Wolfson and Murphy, 1998). Between international trade and SBTC, Freeman and Needels (1993) find a more important role for trade in the U.S., whereas Murphy, Riddell, and Romer (1998) argue in favour of the role of SBTC. Card, Kramarz, and Lemieux (1999) also find that wage changes in Canada are less correlated to SBTC than in the U.S.

Insert Table 1 here

---

\(^1\) For a review of empirical studies related to other countries than the U.S. and Canada, see Grenier and Tavakoli (2006).
III. The Economic Patterns of the Main Variables Related to Wage Inequality

Two kinds of classifications, less-educated versus educated workers, and production versus non-production workers, have been used to distinguish between unskilled and skilled workers (Table 1). In this paper we use the wages of production and non-production workers (WP/WNP) in the manufacturing sector. While this approach limits the research to one sector of the economy, its advantage is that wages can be compared for a relatively long period of time, before and after the advent of globalisation. In Canada, wages by education levels are available only since the early 1980s.

Figure 1 displays the pattern of the WP/WNP ratio in Canada and the U.S. for the four decades covering the period of 1960 to 2001. The wage ratio is higher in Canada than in the U.S., with average values for the entire period of 0.71 and 0.62 respectively. The change patterns, however, are similar in the two countries. During the 1960s, the ratio moved somewhat erratically (Feenstra and Hanson, 2001; Sachs and Shatz, 1994), before increasing during the 1970s (somewhat earlier in Canada than in the U.S.). Since the early 1980s, the WP/WNP ratio has declined at a rate of about 0.8 percent per year in both countries. We select 1980=100 as a benchmark signalling the beginning of globalisation. Figure 2 shows the ratio of the same wages during the period 1970-2001 using this benchmark. All the other variables are compared in the same way.

We now consider some of the variables related to the widening wage gap. There are arguments for a shift in employment away from unskilled workers, explained by demand factors. In the U.S., for example, it is argued that, “the only explanation consistent with the facts is that there has been an outward shift in demand for more-skilled workers since the mid-1980s, leading to an increase in their relative employment and wages” (Feenstra and Hanson, 2001, P.3). However, both demand and supply of skilled workers can explain the widening of the wage gap in the U.S. and Canada. Therefore, beside technological changes, imports from developing countries, and capital stock which mainly affect the demand side of the labour market, union, immigration, and the numbers of production workers are also considered as variables that influence the supply side.

We use total research and development expenditures (R&D/GDP) to proxy technological change (Machin and Van Reenen, 1998; Berman and Machin, 2000; Driffield and Taylor, 2000; Allen, 2001; Grenier and Tavakoli, 2006). We use imports from developing countries (DIM/GDP) to proxy international trade liberalization (Berman et al., 1994; Anderton and Brenton, 1998; Driffield and Taylor, 2000; Grenier and Tavakoli, 2006).

---

2 The unskilled and skilled workers wage rates in a manufacturing sector are defined in terms of production and non-production workers’ wage rates. This classification based on production and non-production jobs dates back to Berndt and Christensen (1974). Berman and Machin (2000, P. 13) report that “trends in the wage and employment rates of non-production vis-à-vis production workers and graduates vis-à-vis non-graduates show very similar trends in the countries for which both measures are available”. For further explanations see Feenstra and Hanson (1999 or 2001, footnote on P.5 and Figure 1 on P.61). However, Learner (1994) criticises the production and non-production classification as representing unskilled and skilled workers jobs.
Developing countries imports were chosen to emphasise North-South trade. Those factors, as well as real capital stock per worker (RMK/L), affect the demand for labour. Union density in the manufacturing sector (MUD), the ratio of immigration to population (IMM/POP), and the ratio of the numbers of production workers to non-production workers (PL/NPL) are variables that affect the supply of labour. The evolutions of those variables are summarized in Table 2 and Figures 3 to 9.

During the period 1970-2001, the average value of the R&D/GDP ratio was 2.5 percent in the U.S. compared to only 1.3 percent in Canada (Table 2 and Figure 3). During the 1970s and the early 1980s, the ratios followed similar patterns of change in both countries, but since then the ratio has grown faster in Canada. Since 1980, it has increased by a high rate of 2.1 percent per year in Canada, compared to only 0.3 percent in the U.S. As a consequence, in Canada the average value of R&D/GDP increased from 1.2 percent in the early 1980s to 1.6 percent in the late 1990s.

Figure 4 shows that the deterioration of manufacturing union density (MUD) in the U.S. started in the early 1970s. In Canada, union density was steady from the early 1970s to the early 1980s, but since then it has declined. Between 1980 and 2001, however, union density deteriorated by a significant rate of 3.7 percent per year in the U.S., while it declined by a slow rate of 1.3 percent in Canada (Table 2).

Between 1970 and 2001, the average value of IMM/POP was about 0.64 percent in Canada and 0.28 percent in the U.S. (Table 2 and Figure 5). During this period, the level of the IMM/POP ratio increased slowly in Canada (about 0.8% per year) but it grew faster in the U.S. (about 2.3% per year). During the early period of 1970 to 1984, the ratio in Canada decreased by the annual rate of 4.6 percent from 0.69 percent in 1970 to about 0.35 percent in 1984. Since 1985 it has increased by 2.8 percent per year to reach the level of 0.80 percent in 2001. In the U.S., on the other hand, the ratio has grown by an annual rate of 2.3 percent during the whole period. During the early period 1970 to 1980 it increased by a rate of about 3 percent per year and since 1981 its level increased at a slow rate of about 1.2 percent.³

The patterns of imports from developing countries to GDP (DIM/GDP) are not the same in the two countries (Table 2 and Figure 6). In Canada, between 1970 and 2001, the ratio moved around its average value of about 3 percent. It grew at a slow rate of 0.9 percent per year during the period of 1970 to 2001. In the early 1980s, the ratio declined for a short period of time and then grew by a significant rate. In the U.S., the average value of the ratio was 3.7 percent during the whole period, higher than in Canada. In the U.S. however, the ratio has grown at a high rate of 3 percent per year and it increased from 1.3 percent in 1970 to 5.7 percent in 2001. But, in the early 1970s and the late 1990s the ratio grew significantly.

³The big jump in immigration rate in the U.S. between 1989 and 1991 is due to the fact that the country permitted illegal immigrants to change their status to legal immigrants.
The ratio of production workers to non-production workers (PL/NPL) has also followed different patterns in each nation (Figure 7). It was about 3 in Canada and 2.4 in the U.S. during the period 1970 to 2001. In Canada, during this period, it grew smoothly at the annual rate of 1.4 percent, compared to a slow and insignificant decline in the U.S. (Table 2). Since the early 1980s the ratio has increased by a significant rate of 2.2 percent per year in Canada. In the U.S., on the other hand, the ratio declined by an annual rate of about 1.2 percent between 1977 and 1994 and since 1995 it has grown significantly. Feenstra and Hanson argue that the increase in the supply of non-production workers in the U.S. could account for the reduction in their relative wage between 1970 to the early 1980s, but was at odds with the increase in the relative wage of non-production workers after that (Feenstra and Hanson, 2001, P.4).

Figure 8 displays the patterns of total employment (L=PL + NPL) in the manufacturing sector. Similar patterns are observed in both countries during the 1970s and the early 1980s. In the U.S., however, total employment declined from the average level of 17.9 million workers in the early 1980s to 17.0 million in the late 1990s. In Canada, on the other hand, the level of employment increased from 1.7 to 1.8 million workers during the same period (Table 2). The level of employment has increased significantly since 1993 in Canada, while it continued to decrease in the U.S. In fact, in the U.S. the level of total employment decreased by the annual rate of 0.5 percent and for a total of about 25 percent during the period 1980 to 2001.

The real capital stock per worker (RMK/L) has grown smoothly in each country during the period 1970 to 2001 (Figure 9). During this period, the ratio grew by an annual rate of 3.2 percent in Canada and 3.3 percent in the U.S. (Table 2). Its value, however, has fluctuated more in Canada than the U.S. The average value of RMK/L ratio in real term was about CAN$ 39 and US$ 50 thousands in Canada and in the U.S. for the entire sample period.

IV. Model Specification and Estimation Results:

We specify the wage ratio (WP/WNP) as a function of various national and international variables affecting the demand for and supply of skilled and unskilled workers in the manufacturing sector. Based on previous work by Katz and Murphy (1992), Velde and Morrissey (2002) and Banga (2005) who assume a CES production function with two factors of production, skilled (Ls) and unskilled (Lu) workers, the wage ratio in a competitive market can be shown to be:

\[
\frac{W_u}{W_s} = \frac{MP_{L_s}}{MP_{L_u}} = \frac{\beta}{\alpha} \left( \frac{B_2}{B_1} \right)^{-\rho} \left( \frac{L_u}{L_s} \right)^{-(1+\rho)}
\]

Bernstein, Harris, and Sharpe (2002, P.4) also observe a similar pattern for the sub-period 1989-2001.
where $\alpha$, $\beta$ and $\rho$ are the parameters of the production function and $B_1$ and $B_2$ are efficiency units affecting the productivity of each of the two factors. The wage ratio depends on the relative efficiencies of the two kinds of labour and on the number of workers in the two skill levels, assumed exogenous. The efficiency units are further assumed to be affected, directly or indirectly through economic externalities, by R&D, outsourcing factors, such as imports, and other factors that vary through time. For example, increased R&D expected to make skilled workers more productive relative to unskilled workers. This leads to the empirical model that we estimate. The data appendix at the end of the paper provides a precise definition of all the variables used and of their sources.

\[
\frac{WP_t}{WNP_t} = F\left(\frac{R & D_t}{GDP_t}, \frac{IMM_t}{POP_t}, \frac{DIM_t}{GDP_t}, MUD_t, \frac{RMK_t}{L_t}, \frac{PL_t}{NPL_t}\right) + \varepsilon_t,
\]

$t=1970, \ldots, 2001,$

where,

WP: Average annual production wage rate,
WNP: Average annual non-production wage rate,
R&D: Total research and development expenditures,
GDP: Gross domestic product,
IMM: Total immigration,
POP: Total population,
DIM: Total value of imports from developing countries,
MUD: Manufacturing union density,
RMK: Total real capital stock in manufacturing sector,
PL: Total production employment,
NPL: Total non-production employment,
L: Total employment (PL+NPL),
t: time period,
\( \varepsilon \): Error term with classical assumptions,

The variables R&D/GDP, DIM/GDP, IMM/POP, and MUD are in percentages. WP/WNP and PL/NPL are in share terms, where RMK/L is in real value term.

Equation (1) can be interpreted as a reduced form equation derived from labour market equilibrium. As explained before, some variables affect mainly the demand side of the labour market and some influence mainly the supply side.

A positive change in each of the globalisation variables (R&D/GDP, DIM/GDP) is expected to have a negative impact on the demand for unskilled workers and cause the wage ratio to decline. Similarly, as a result of increasing the immigration ratio (IMM/POP) and/or production employment to non-production employment ratio (PL/NPL), the supply of unskilled labour increases and consequently there will be a negative effect on the wage ratio. A deterioration of labour union power measured by a decrease in union density (MUD) has a negative impact on unskilled labour’s position in
the market. It is also expected that an increase in manufacturing capital-labour ratio (RMK/L) will affect the demand for unskilled labour positively.

As mentioned in the previous section, the ratio of R&D expenditures to GDP is used as a proxy for technical change in the manufacturing sector, and import intensity, measured by the ratio of imports from developing nations to GDP, is used as a proxy for international trade liberalization effect.

A simple linear function among variables is applied to Equation 1 to estimate the effect of globalisation on the wage inequality in each country. The OLS method is applied to estimate the relationship.

Two dummy variables, which account for the structural changes, and a time trend, are also included in Equation 1 for each country. In the case of Canada, the dummy variable DCA is used to account for the structural change in the wage ratio that started in the early 1980s, taking the value 1 for all the years between 1982 and 2001 (Figure 2). The dummy variable DCA is also applied in interaction with the DIM/GDP ratio as its level declined around the early 1980s for a short period of time and then grew significantly later on (Figure 6). Another dummy variable DCA1 is also used to account for the change in the data source for union density after 1996 (see the data appendix).

In the case of the U.S., the dummy variable DUS is applied to account for the structural change in the wage ratio that started in the late 1970s, taking the value 1 for all the years between 1980 and 2001. In addition, since the DIM/GDP ratio grew significantly during the early 1970s and the late 1990s, and since the PL/NPL share declined between 1977 and 1994 but its level has increased considerably since then, the dummy variable DUS1 is used in interaction with both DIM/GDP and PL/NPL ratios, taking the value 1 for all the years between 1970 and 1976 and between 1995 and 2001.

Because of the high level of collinearity between R&D/GDP and MUD variables, the regression that includes these two variables in Equation 1 did not provide good results and is not shown. Therefore, our data do not allow separating the effects of those two variables. Instead, the effects of globalisation are considered when R&D and union appear in separate regressions. Furthermore, in the case of the U.S., as Figure 2 shows, the WP/WNP ratio just declined between 1980 and 1999 and since then the ratio has started to increase; therefore, we exclude the last two years from the estimated results.

The OLS estimation results are collected in Table 3. It is observed that most coefficients have a priori expected signs and they are statistically significant. The estimated coefficient of RMK/L variable is not statistically significant and in one case it has the wrong sign. In the case of Canada, the immigration variable has the a priori sign but its estimated value is not statistically significant. The adjusted R-squared are relatively high. The value of the Durbin-Watson statistics is relatively high to reject the serial correlation problem among error terms. The estimated error term is behaving normally as the $\chi^2_n$ (2)
statistics shows. The value of $\chi^2_H$ statistics does not indicate that heteroscedasticity is problem.\(^5\)

Insert Table 3 here

Insert Table 4 here

Since the negative effect of imports on the wage gap is not observed for the whole sample period, a dummy variable in interaction with the DIM/GDP was used to account for its effect during a sub-period. In case of Canada, the DIM/GDP variable had the negative and statistically significant effect on the wage ratio for the sub-period 1982 to 2001. Similarly, the effects of DIM/GDP and PL/NPL variables were statistically significant for some particular periods in the U.S.

For comparisons, the OLS estimated coefficients are converted into elasticities around their mean values. The results are shown in Table 4. Other than the technological change effect, this table shows that the effect of economic globalisation on the wage gap is relatively higher in Canada. There are, however, some differences between the two nations:

- Among the independent variables, the impact effect of union density (MUD) on the wage ratio is relatively higher in Canada.
- The effect of technological change (R&D/GDP) on the wage ratio is relatively higher in the U.S. This is consistent with others’ findings that wage changes in Canada are less correlated to SBTC than in the U.S.
- The effect of imports from developing nations (DIM/GDP) on the wage gap is more pronounced in Canada.
- The effect of production to non-production workers (PL/NPL) on the wage gap is more pronounced in Canada.
- The effect of immigration on the wage ratio is small in each nation, and its effect is not statistically significant in Canada.

The coefficients of the dummy variables DUS and DCA show that the wage gap has widened as a consequence of structural changes in each nation. In addition, the positive effect of time trend on the wage ratio demonstrates an economic improvement in the MUD equation in Canada compared to the opposite effect in the R&D/GDP equation in the U.S.

\(^5\)To check for the possibly of simultaneity problem between the dependent variable WP/WNP and independent variable PL/NPL in equation 1, the exogeneity test of independent variable was applied (Nakamura and Nakamura, 1981). The test confirms the exogeneity of PL/NPL variable. Furthermore, the augmented Dickey-Fuller (ADF) tests for cointegration among variables were applied to check for the appropriateness of the estimated OLS equation. The results indicate that the null hypothesis of non-stationary is not rejected for the levels of the majority of but it is rejected for the first and second differences in Canada and the U.S., respectively. Since in each country both dependent and explanatory variables included in an equation have the same order of integration and they are stationary, the estimated equation using the OLS technique is proper and the estimation results cannot give rise to the phenomenon of spurious regression (Nelson and Plosser, 1982; Phillips, 1987).
V. Concluding Remarks:

In this paper, we considered the effects of economic globalisation on the wages of production and non-production workers in the manufacturing sector in Canada and the U.S. from the early 1970s to the early 2000s. Those two countries have some common economic characteristics, but they also differ in their institutions. The results show that the wage ratio is affected by similar economic globalisation variables in each country. We found that both technological change and imports from developing countries have widened the wage gap in each country, with the former having a more important effect than the latter. This is consistent with a large number of earlier studies that favour skilled-biased technological change over international trade as the main cause of the deterioration of the economic position of low-skilled workers We also found that labour supply factors such as the deterioration of union power and the change in the number of production workers had a negative impact on the position of unskilled workers. On the other hand, immigration did not play a major role as a supply factor. This is also consistent with what other studies have found.

While the wage ratio is affected by similar economic variables in each country, there are some differences. The overall effect of trade with developing countries appears to be more pronounced in Canada. In contrast, the effect of technological changes is higher in the U.S. Among other variables, the wage gap is more affected by union density in Canada.
Data Appendix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable:</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Average wage of production workers divided by average wage of non-production workers in manufacturing | *Canada:* Annual Survey of Manufactures. Cansim II tables 301-0001, 301-0002 and 301-0003 all together cover the period 1970-2001.* The data information for total production and non-production employment and wages are missing for year 1987. The missing data is calculated using an estimated growth variable rate from the available information in the early period (1970-1986).  
| **Independent variables:**                                               |                                                                        |
| Research and development expenditures as a proportion of GDP            | *Canada:* Cansim II table 358-0001 for R&D and table 380-0030 for GDP.  
| Total immigration divided by population                                  | *Canada:* Cansim II table 051-0011 for immigration and table 051-0001 for population.  
| Imports from developing countries divided by GDP                         | *Canada and the U.S.A.:* IMF (various issues). Direction of Trade Statistics, Washington, D.C. Calculated from total imports minus imports from industrial nations. |
| Manufacturing union density                                             | *Canada:* Cansim II tables 279-0024, 279-0026, 282-0078. Until 1995, union statistics were collected under the Corporations and Labour Union Returns Act. Starting in 1997, union data are collected by the Labour Force Survey. There is a break in the data because of the two different methodologies. Furthermore, there are no data for 1996. The dummy variable D1 was defined to take account of this break. As the data point for 1996, we took the average of 1995 and 1997.  
| Manufacturing capital stock divided by number of total workers           | *Canada:* Annual Survey of Manufactures. Cansim II tables 301-0001, 301-0002 and 301-0003. Capital is approximated as manufacturing value added minus the wage bills of production and non-production workers. The GDP deflator deflates the ratio.  
| Number of production workers divided by the number of non-production workers | *Canada:* Annual Survey of Manufactures. Cansim II tables 301-0001, 301-0002 and 301-0003. See the comment above for the dependent variable about the short and long form questionnaires and the possible overestimation of the number of production workers.  

*Note: There are two survey questionnaires: a long form and a short form. Only the long form questionnaire provides separate data for production and non-production (administrative) workers. Nearly 45% of establishments, representing about 90% of total value, receive the long form questionnaire. The short form questionnaire is used to collect information for small establishments. Since most employees of small establishments are production workers, it is assumed that all employees from the short form questionnaire are production workers. This procedure overestimates somewhat the population of production workers. Note that Baldwin and Rafiquzzaman (1998) use only data from long form questionnaires and have different estimation of the number of production and non-production workers.*
References:


---------- and Hanson, Gordon H. 2001. “Global Production Sharing and Rising Inequality: A Survey of Trade and Wages,” NBER WP.8372 (July),


Velde, Dirk Willem te and Morrissey, Oliver (2002) “Foreign Direct Investment, Skills and Wage Inequality in East Asia” Paper presented at DESG conference in Nottingham, April 2002


Table 1: Selected Empirical Findings on the Effect of Technical Change, International Trade, Immigration on Wage Gap (Based on low-skilled and Skilled Classification Workers)

<table>
<thead>
<tr>
<th>Study</th>
<th>T</th>
<th>C</th>
<th>I</th>
<th>U</th>
<th>Classification, Data, and Model</th>
<th>Classification and Data Information</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borjas, Freeman, Katz (1992)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>LE&amp;E, Cross-section (States)</td>
<td>FC</td>
<td></td>
</tr>
<tr>
<td>Bound, Johnson (1992)</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>LE&amp;E, Panel</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Katz, Murphy (1992)</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>LE&amp;E, Panel, 4-digits SIC</td>
<td>FC</td>
<td></td>
</tr>
<tr>
<td>Berman, Bound, Griliches (1994)</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>P&amp;NP, Panel, 4-digit SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Borjas, Ramey (1994)</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td>LE&amp;E, Time series</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Sachs, Shatz (1994)</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
<td>P&amp;NP, Panel, 3-digits SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Borjas, Freeman, Katz (1996)</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
<td>LE&amp;E, Cross-section</td>
<td>FC, R</td>
<td></td>
</tr>
<tr>
<td>Feenstra, Hanson (1996)</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>P&amp;NP, Panel, 4-digit SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Baldwin, Cain (1997)</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>P&amp;NP</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Borjas, Freeman, Katz (1997)</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td>LE&amp;E, Cross-section (States)</td>
<td>FC, R</td>
<td></td>
</tr>
<tr>
<td>Anderton, Brenton (1998)</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>P&amp;NP, Panel, 4-digit SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Feenstra, Hanson (1999)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>P&amp;NP, Panel, 4-digit SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Allen (2001)</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>LE&amp;E, Panel, 4-digit SIC</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

Canada

<table>
<thead>
<tr>
<th>Study</th>
<th>T</th>
<th>C</th>
<th>I</th>
<th>U</th>
<th>Classification, Data, and Model</th>
<th>Classification and Data Information</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zakhilwal (2000)</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>LE&amp;E, Panel, 3-digit SIC</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

Canada and the U.S.A.

<table>
<thead>
<tr>
<th>Study</th>
<th>T</th>
<th>C</th>
<th>I</th>
<th>U</th>
<th>Classification, Data, and Model</th>
<th>Classification and Data Information</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betts (1997)</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
<td>P&amp;NP, Panel, 2-digit SIC</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Murphy, Riddell, Romer (1998)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>LS&amp;E, Panel, Microdata</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors’ collection.
Table 2: The Average Values and Growth Rates of Main Variables

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>WP/WNP (Ratio)</th>
<th>RD/GDP (%)</th>
<th>MUD (%)</th>
<th>IMM/POP (%)</th>
<th>DIM/GDP (%)</th>
<th>PL/NPL (Ratio)</th>
<th>Total PL + NPL (Million)</th>
<th>RMK/L ($1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>71-75</td>
<td>.72</td>
<td>1.0</td>
<td>43.6</td>
<td>.75</td>
<td>3.0</td>
<td>2.5</td>
<td>1.7</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>76-80</td>
<td>.76</td>
<td>0.9</td>
<td>43.9</td>
<td>.52</td>
<td>3.2</td>
<td>2.7</td>
<td>1.8</td>
<td>29.8</td>
</tr>
<tr>
<td></td>
<td>81-85</td>
<td>.74</td>
<td>1.2</td>
<td>41.3</td>
<td>.41</td>
<td>2.5</td>
<td>2.6</td>
<td>1.7</td>
<td>33.4</td>
</tr>
<tr>
<td></td>
<td>86-90</td>
<td>.70</td>
<td>1.4</td>
<td>36.4</td>
<td>.62</td>
<td>2.5</td>
<td>3.1</td>
<td>1.9</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>91-95</td>
<td>.69</td>
<td>1.6</td>
<td>33.5</td>
<td>.82</td>
<td>3.3</td>
<td>3.1</td>
<td>1.6</td>
<td>43.3</td>
</tr>
<tr>
<td></td>
<td>96-00</td>
<td>.65</td>
<td>1.6</td>
<td>34.6</td>
<td>.68</td>
<td>3.7</td>
<td>3.7</td>
<td>1.8</td>
<td>58.7</td>
</tr>
<tr>
<td></td>
<td>70-01</td>
<td>.71</td>
<td>1.3</td>
<td>38.7*</td>
<td>.64</td>
<td>3.0</td>
<td>3.0</td>
<td>1.8</td>
<td>38.6</td>
</tr>
<tr>
<td></td>
<td>GR:80-01</td>
<td>-0.8</td>
<td>2.1</td>
<td>-1.3</td>
<td>3.0</td>
<td>2.2</td>
<td>2.2</td>
<td>0.2</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>GR:70-01</td>
<td>-0.5</td>
<td>2.0</td>
<td>-1.2*</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
<td>0.2</td>
<td>3.2</td>
</tr>
<tr>
<td>USA</td>
<td>71-75</td>
<td>.63</td>
<td>2.2</td>
<td>37.6</td>
<td>.18</td>
<td>2.5</td>
<td>2.4</td>
<td>19.1</td>
<td>30.5</td>
</tr>
<tr>
<td></td>
<td>76-80</td>
<td>.65</td>
<td>2.2</td>
<td>34.4</td>
<td>.22</td>
<td>3.9</td>
<td>2.7</td>
<td>19.1</td>
<td>39.8</td>
</tr>
<tr>
<td></td>
<td>81-85</td>
<td>.65</td>
<td>2.5</td>
<td>28.2</td>
<td>.24</td>
<td>3.5</td>
<td>2.4</td>
<td>17.9</td>
<td>43.2</td>
</tr>
<tr>
<td></td>
<td>86-90</td>
<td>.62</td>
<td>2.6</td>
<td>22.3</td>
<td>.36</td>
<td>3.4</td>
<td>2.3</td>
<td>17.6</td>
<td>53.2</td>
</tr>
<tr>
<td></td>
<td>91-95</td>
<td>.60</td>
<td>2.5</td>
<td>19.0</td>
<td>.40</td>
<td>4.0</td>
<td>2.3</td>
<td>17.0</td>
<td>61.6</td>
</tr>
<tr>
<td></td>
<td>96-00</td>
<td>.57</td>
<td>2.6</td>
<td>15.9</td>
<td>.28</td>
<td>5.4</td>
<td>2.5</td>
<td>16.9</td>
<td>72.7</td>
</tr>
<tr>
<td></td>
<td>70-01</td>
<td>.62</td>
<td>2.5</td>
<td>25.1*</td>
<td>.28</td>
<td>3.7</td>
<td>2.4</td>
<td>17.9</td>
<td>50.1</td>
</tr>
<tr>
<td></td>
<td>GR: 80-01</td>
<td>-0.8</td>
<td>0.3</td>
<td>-3.7</td>
<td>1.2</td>
<td>2.4</td>
<td>0.2*</td>
<td>-0.5</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>GR: 70-01</td>
<td>-0.4</td>
<td>0.6</td>
<td>-3.7*</td>
<td>2.3</td>
<td>3.3</td>
<td>-0.1*</td>
<td>-0.5</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Source: Authors’ calculation (see Appendix for the sources of databases). * Calculations are based on the 1971-2001 period for Canada and the 1973-2001 period for the US. GR: Growth Rate
Table.3: Technical Change, Union, Immigration, and Imports Effects on Wage Ratio
(OLS Estimation)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.65 (8.1)****</td>
<td>0.52 (12.5)****</td>
<td>0.76 (25.2)****</td>
<td></td>
</tr>
<tr>
<td>MUD</td>
<td>0.0039 (2.8)****</td>
<td>0.0037 (2.9)****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D/GDP</td>
<td>-0.005 (0.3)</td>
<td>-0.027 (3.4)****</td>
<td></td>
<td>-0.020 (3.0)****</td>
</tr>
<tr>
<td>IMM/POP</td>
<td>-0.004 (0.6)</td>
<td>-0.010 (2.7)**</td>
<td></td>
<td>-0.018 (4.3)****</td>
</tr>
<tr>
<td>DIM/GDP</td>
<td>-0.020 (1.9)**</td>
<td>-0.026 (3.9)*****</td>
<td></td>
<td>-0.032 (7.0)****</td>
</tr>
<tr>
<td>DCA1(DIM/GDP)</td>
<td>0.008 (2.1)*</td>
<td>0.015 (1.3)</td>
<td></td>
<td>0.026 (3.5)****</td>
</tr>
<tr>
<td>DUS1(DIM/GDP)</td>
<td>-0.043 (3.8)****</td>
<td>-0.026 (3.9)*****</td>
<td></td>
<td>-0.032 (7.0)****</td>
</tr>
<tr>
<td>PL/NPL</td>
<td>0.00006 (1.7)</td>
<td>0.00001 (0.2)</td>
<td></td>
<td>0.0003 (0.4)</td>
</tr>
<tr>
<td>DCA1</td>
<td>0.035 (3.8)****</td>
<td>0.27 (6.1)*****</td>
<td></td>
<td>0.041 (7.5)****</td>
</tr>
<tr>
<td>DUS</td>
<td>0.055 (1.9)**</td>
<td>-0.027 (6.1)*****</td>
<td></td>
<td>-0.003 (2.8)****</td>
</tr>
<tr>
<td>Trend</td>
<td>0.005 (4.2)****</td>
<td>0.972</td>
<td></td>
<td>0.979</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.949</td>
<td>0.972</td>
<td>0.6201</td>
<td>0.6209</td>
</tr>
<tr>
<td>Mean-value Dep.</td>
<td>1.9</td>
<td>1.8 [seML(2)]</td>
<td>2.0 [seML(1)]</td>
<td>2.3 [seML(1)]</td>
</tr>
<tr>
<td>N</td>
<td>31</td>
<td>32</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>$\chi^2_N(2)$</td>
<td>0.42</td>
<td>0.52</td>
<td>1.11</td>
<td>0.92</td>
</tr>
<tr>
<td>$\chi^2_H(1)$</td>
<td>0.01</td>
<td>0.69</td>
<td>0.04</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Note: t- Statistics are in brackets. *, **, and *** are 10%, 5%, and 1% significant levels, respectively.

WP: Production Worker Annual Average Wage Rate, WNP: Non-production Worker Annual Average Wage Rate, R&D: Total R&D Expenditures, GDP: Gross Domestic Products, IMM: Total Immigration, POP: Total Population, DIM: Total Imports from Developing Nations, MUD: Manufacturing Union Density, RMK: Real Capital Stock in Manufacturing Sector, PL: Production Workers, NPL: Non-production Workers, L: Total Production and Non-production Workers, Trend: Time trend, $\chi^2_H(2)$: Based on a test of skewness and Kurtosis of residuals, $\chi^2_N(2)$: Based on the regression of squared residuals on squared fitted values.


Table.4: Estimated Elasticity Coefficients

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>USA</td>
<td></td>
<td></td>
<td>Canada</td>
<td>USA</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>MUD</td>
<td>+.213</td>
<td>-.145</td>
<td>-.114</td>
<td>-.114</td>
<td>-.178</td>
<td>-0.005* to -0.029</td>
<td>+.213</td>
</tr>
<tr>
<td>R&amp;D/GDP</td>
<td>-.023^</td>
<td>-.013</td>
<td>-.005n</td>
<td>-.09n</td>
<td>-.005n</td>
<td>-.009 to -.023^</td>
<td>-.114</td>
</tr>
<tr>
<td>IMM/POP</td>
<td>-.019^</td>
<td>-.078</td>
<td>-.063</td>
<td>+.035n</td>
<td>-.089</td>
<td>-.012 to -.054^</td>
<td>-.145</td>
</tr>
<tr>
<td>DIM/GDP</td>
<td>-.165</td>
<td>+.057^</td>
<td>-.109</td>
<td>-.182</td>
<td>+.110</td>
<td>-.129 to -.165</td>
<td>-.178</td>
</tr>
<tr>
<td>PL/NPL</td>
<td>-.006</td>
<td>-.092</td>
<td>-.012</td>
<td>-.145</td>
<td>-.178</td>
<td>-.006 to -.028*</td>
<td>-.178</td>
</tr>
</tbody>
</table>

Source: Table.3. ‘n’ indicates statistically not significant.