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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 other variables, the wage gap is more affected by the union variable in Canada. The impact of immigration on the wage gap is low in both nations.

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 mobility (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, whereas countries with centralised wage-setting institutions either escaped the trend toward greater inequality or experienced relatively mild increases (Gottschalk, 1997, P.34).

This study presents an overview of some recent empirical findings and examines the evolution of wage inequality in Canada and the U.S. for production and non-production workers in the manufacturing sector. Following this introduction, 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 concluding remarks are summarised in the last section.

II. Survey of Empirical Findings

A number of empirical studies have shown that economic globalisation, such as international trade liberalisation, technical changes, and international labour mobility, 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 in the era of globalisation, therefore, leads to downward pressures on labour standards (Campbell, 1994; Richardson, 1995; Lee, 1997; Rodrik, 1997; Wood, 1998; Freeman, 1998; Leamer, 2000). Beside, in this process there is no room for legislation to protect workers. In other words, in the age of trade liberalisation for trade unions the regulation of markets becomes difficult because there exists no jurisdictions comparable to national states (Ross, 2000).

There have been some 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 be effective on wage inequality in most developed nations. Its level is about 2 percent in the OECD nations, and for the U.S. which is at the centre of the argument, it is around 4 percent. It is argued, therefore, that trade flows of this limited magnitude cannot explain the large changes in relative wages of skilled workers to unskilled workers 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. The SBTC brings shifts in labour demand and increases wage differentials between skilled and unskilled workers because the marginal product of skilled workers increases. Therefore, most studies that have examined the causes of demand shifts for skilled workers conclude that the SBTC accounts for a large share of the rise in wage inequality (Krueger, 1993; Berman et al., 1994; Burtless, 1995; 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 Raiquiuzzaman, 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). However, other studies cast doubt on the effect of immigration and find that immigration has only a negligible effect on the wages of unskilled (Friedberg and Hunt, 1995; Topel, 1997).

The effect of union on the 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 decline (DiNardo and Lemieux, 1997, Grenier and Tavakoli, 2003).

It can be seen from Table 1 that in the U.S. and Canada most studies focused on the effects of technical changes and international trade, as opposed to union and immigration.
The data and models vary. Most studies are based on regression analysis, but other methods such as factor content and cluster analysis are also used.

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, 1994 and 1998; Slaughter and Swagel, 1997; Feenstra and Hansen, 2001). The effect is found to be between small and a moderate (Richardson, 1995; Cline, 1997; Baldwin and Cain, 1997; Slaughter, 1998). Accounting for the effects of both trade and immigration, 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).

According to the U.S. Economic Report of President, the contributing factors in widening the wage gap in the U.S. can be categorized as follows: technical changes (45%), international trade (12%), decline in unionization (10%), decline in the real minimum wage (10%), rising immigration (8%), and other causes (15%) (Quoted in Lerman, 1997, P.17).

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). Including both trade and SBTC effects, it is argued that the types of technologies have also contributed to the wage gap (Baldwin and Rafiquzzaman, 1998, P.39). Some studies further conclude for the importance of deunionization on wage inequality (Lemieux, 1998; DiNardo and Lemieux, 1997; Grenier and Tavakoli, 2003).

Comparing the two nations, the empirical studies find 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 wages of skilled to unskilled workers increased sharply in the U.S. but fell slightly in Canada (Richardson, 1997; Murphy et al., 1998; Wolfson and Murphy, 1998). There are also some evidences based on widening wages between genders and/or workers by age group (Burbidge, Magee et al., 1995; Morissette, 1996; Burbidge et al., 2002; Heisz et al., 2002).

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 also find that wage changes in Canada are less correlated to SBTC than in the U.S. Whereas in the U.S. lower-wage workers, compared to higher-wage workers, are less likely to adopt computer technologies and suffer significant real wage declines, in Canada this relationship is slightly weaker (Card et al., 1999, P.869).

1 For the review of empirical studies related to other countries than the U.S. and Canada, see Grenier and Tavakoli (2003).
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>TC</th>
<th>IT</th>
<th>I</th>
<th>U</th>
<th>Classification, Data, and Model</th>
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<td>Bound, Johnson (1992)</td>
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<td>Katz, Murphy (1992)</td>
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<td>LE&amp;E Panel, 4-digits SIC</td>
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<tr>
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<td>+</td>
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<td>P&amp;NP Panel, 4-digit SIC</td>
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<td></td>
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<td>+</td>
<td></td>
<td></td>
<td>LS&amp;E Panel, Microdata</td>
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</table>

Source: Authors’ collection.


III. The Economic Patterns of the Main Variables Related to Wage Inequality

In studies about Canada and the U.S., two kinds of classifications, less-educated and educated workers versus production and non-production workers, have been applied extensively to distinguish between unskilled and skilled workers (see Table 1). In this paper we use the wages of production and non-production workers (WP/WNP) in the manufacturing sector to compare unskilled and skilled workers.

Figure 1 displays the pattern of the WP/WNP ratio in Canada and the U.S. for the period

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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 dating 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 explanation see Feenstra and Hanson (1999 or 2001, the footnote on P.5 and Figure 1 on P.61). However, Leamer (1994) criticises the production and non-production classification as unskilled and skilled workers jobs.
of 1960 to 2001. The figure shows that the wage ratio is relatively higher in Canada than in the U.S. In Canada, the average value of the ratio for the entire period is 0.71, while it is 0.62 in the U.S. The change patterns, however, are similar in the two countries. During the 1960s and 1970s, the ratio moved erratically in the U.S. (Feenstra and Hanson, 2001, Sachs and Shatz, 1994,). In Canada, the ratio dipped in the early 1960s, rose and fluctuated without trend during the rest of the decade, and narrowed between 1970 and 1977.

Since the late 1970s and early 1980s, the WP/WNP ratio has declined at a rate of about 0.8 percent per year in both nations. In other words, wage inequality between low-skilled and more-skilled workers has taken place at the same pace in both countries. The approximate time of the beginning of the decline is around the late 1970s and the early 1980s. In the present study we select 1980=100 as a benchmark of comparison. Figure.2 shows the ratio of the same wages during the period 1970-2001 using that index. All the other variables will be compared in the same way.

Among the reasons for the widening wage gap between low-skilled and more-skilled workers, there are arguments for a shift in employment away from skilled 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.

In the present paper we use total research and development expenditures to GDP (R&D/GDP) and imports from developing countries to GDP (DIM/GDP) to measure technological changes and international trade liberalization, respectively, and real capital stock per worker (RMK/L), as factors that 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 economic patterns of these variables are both 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 (see Table 2). During the 1970s and the early 1980s, the R&D/GDP ratios followed similar patterns in both nations and since then it has started to grow faster in Canada (see Figure.3). Since 1980 the ratio has increased by a high rate of 2.1 percent per year in Canada compared to a low rate of 0.3 percent in the U.S. As a consequence, in Canada the average value of R&D/GDP ratio increased from 1.2 percent in the early 1980s to 1.6 percent in the late 1990s (see Table 2).
Figure 1: Manufacturing WP/WNP Ratio (1961-2001)

Figure 2: Trend of WP/WNP Ratio (1980=100) 1970-2001

Figure 3: Trend of R&D/GDP Ratio (1980=100) 1970-2001

Figure 4: Trend of MUD (1980=100) 1970-2001

Figure 5: Trend of IMM/POP Ratio (1980=100) 1970-2001

Figure 6: Trend of DIM/GDP Ratio (1980=100) 1970-2001

Figure 7: Trend of PL/NPL (1980=100) 1970-2001

Figure 8: Trend of Total Employment (1980=100) 1970-2001

Figure 9: Trend of RMK/L Ratio (1980=100) 1970-2001
Table 2: The Average Values and Growth Rates of Main Variables

<table>
<thead>
<tr>
<th>Country</th>
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<th>RD/GDP (%)</th>
<th>MUD (%)</th>
<th>IMM/POP (%)</th>
<th>DIM/GDP (%)</th>
<th>PL/NPL (Ratio)</th>
<th>Total PI &amp; NPL (Million)</th>
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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. ** indicates statistically insignificant value. GR: Growth

“Union densities in the two nations tracked each other until late 1960s and the early 1970s, when unionization began to decline in the U.S. while rising in Canada” (DiNardo and Lemieux, 1997, P.632). In Canada, however, unionization shifted from traditional less-skilled industries such as natural resources, manufacturing, and construction, toward service based industries, while in the U.S. unionism uniformly declined in all industries except public administration (DiNardo and Lemieux, 1997, P.633). As a consequence, the manufacturing union density (MUD) declined in both Canada and the U.S. in the last two decades (see Figure 4).

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

Between 1970 and 2001, the average value of IMM/POP ratio was about 0.64 percent in Canada and 0.28 percent in the U.S. (see Table 2). 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 1970 to 1984 the ratio 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 0.80 percent by 2001 (see Table 2). 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 by a slow rate of about 1.2 percent. As Figure 5 shows, however, there was a big jump in immigration rate in the U.S.
1989 and 1991 when the country permitted illegal immigrants to change their status to legal immigrants. In the U.S., immigrants make up about 7 percent of workforce, or more than 17 percent of the workforce, with less than a high-school degree, and over 90 percent of immigrants comes from low-wage countries (Lerman, 1999, P.24).

The patterns of DIM/GDP ratios are different in both nations (see Figure.6). In Canada, between 1970 and 2001, the import ratio was moving around its average value (about 3 percent). The ratio has grown by a slow rate of 0.9 percent per year during the period 1970 to 2001. Around the early 1980s, the ratio declined for a short period of time and then it grew by a significant rate (see Figure.6). In the U.S., the average value of the ratio was 4 percent during the whole period, higher than the ratio 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 (see Table 2). However, in the early 1970s and the late 1990s the ratio grew significantly (see Figure.6).

The numbers of production workers to non-production workers (PL/NPL) has also followed different patterns in each nation (see Figure.7). The share of production workers to non-production workers (PL/NPL) was about 3 in Canada and 2.4 in the U.S. during the period 1970 to 2001. In Canada, during this period the PL/NPL ratio grew smoothly by the annual rate of 1.4 percent, compared to a slow and insignificant decline in the U.S. (see 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 (see Figure.7). Feenstra and Hansen argue that the increase in the supply of non-production workers in the U.S. could account for the reduction in its 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 Hansen, 2001, P.4).

Figure.8 also displays the patterns of total employment (PL plus NPL) in the manufacturing sectors. The figure shows that total employment follows similar patterns in both nations 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 (see Table 2). The level of employment has increased significantly since 1993 in Canada, while it continued to decrease in the U.S. (see Figure.8). 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 workers (RMK/L) has grown smoothly in each country within the sample period (see Figure.9). During the period 1970 to 2001 the ratio grew by an annual rate of 2.8 percent in Canada and 3.3 percent in the U.S. (see Table 2). Its value, however, has fluctuated more in Canada than the U.S. The value of RMK/L ratio in real

3 Bernstein, Harris, and Sharpe (2002, P.4) also observe a similar pattern for the sub-period 1989-2001.
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 both the demand for and supply of skilled and unskilled workers in the manufacturing sector. Then the model of the following equation is applied to investigate the effect of various dimensions of globalisation on wage inequality in the Canadian and U.S. manufacturing sectors. A simple linear equation of all variables is estimated. The data appendix at the end of the paper provides a precise definition of all the variables used and of their sources.

\[
\frac{W^p_t}{W^{np}_t} = F\left(\frac{R&D_t}{GDP_t}, \frac{IMM_t}{POP_t}, \frac{DIM_t}{GDP_t}, \frac{MUD_t}{L_t}, \frac{RMK_t}{NPL_t}\right) + \varepsilon_t, \quad t=1970, \ldots, 2001,
\]

where,

- \(W^p_t\): Average annual production wage rate,
- \(W^{np}_t\): Average annual non-production wage rate,
- R&D: Total research and development expenditures,
- GDP: Gross domestic products,
- 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 the labour market equilibrium for unskilled and skilled workers in the manufacturing sector. There are two groups of variables affecting the labour market equilibrium: the R&D/GDP, DIM/GDP, and RMK/L variables affect mainly the demand side of the labour market and the IMM/POP, PL/NPL, and MUD variables influence mainly the supply side.

It is expected that a positive change in each of the globalisation variables (R&D/GDP, DIM/GDP) 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. Therefore, the change in MUD will influence the wage ratio in the same direction. It is also expected that an increase in manufacturing capital-labour ratio (RMK/L) will affect the demand for unskilled labour positively.

The ratio of R&D expenditures to GDP is used as a proxy for technical change effect in the manufacturing sector (Berman, Bound, John, Griliches, 1994; Machin and Van Reenen, 1998; Berman and Machin, 2000; Driffield and Taylor; 2000, Allen, 2001). The import intensity, measured by the ratio of imports from developing nations to GDP, is used as a proxy for international trade liberalization effect (Berman, bound, and Griliches, 1994; Anderton and Brenton, 1998; OECD, 1998; Driffield and Taylor, 2000).

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 variable, for any missing variables, are also included in Equation 1. In case of Canada, the dummy variable DCN 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 (see Figure.2). The dummy variable DCN 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 it has grown significantly later on (see Figure.6). The dummy variable DCN1 is further used that includes union density because of the change in the data source after 1996 (see the data appendix).

In 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. Further, 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. As we have already argued, the DIM/GDP ratio grew significantly in the early 1970s and in the late 1990s. During these two periods a strong correlation is found between both WP/WNP and DIM/GDP variables. The PL/NPL ratio, on the other hand, declined during the period 1977 to 1994 but it has grown significantly since then.

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 to disentangle 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 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 two recent periods from the estimated results.

---

4 The simple correlation coefficients between WP/WNP and DIM/GDP ratios are –0.87 (for 1970-1976) and –0.82 (for 1995-1999), where the correlation is –0.45 for the entire period (1970-1999).
### Table 3: Technical Change, Union, Immigration, and Imports Effects on Wage Ratio

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Canada</th>
<th>USA</th>
<th>Canada</th>
<th>USA</th>
<th>Canada</th>
<th>USA</th>
<th>Canada</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Union</td>
<td>Technical Change</td>
<td>Union</td>
<td>Technical Change</td>
<td>Union</td>
<td>Technical Change</td>
<td>Union</td>
<td>Technical Change</td>
</tr>
<tr>
<td>Constant</td>
<td>0.65 (8.1)***</td>
<td>0.88 (22.2)***</td>
<td>0.52 (12.5)***</td>
<td>0.76 (25.2)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>MUD</td>
<td>0.0039 (2.8)***</td>
<td>-----</td>
<td>0.0037 (2.9)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>R&amp;D/GDP</td>
<td>-----</td>
<td>-0.062 (2.4)***</td>
<td>-----</td>
<td>-0.045 (4.2)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
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</tr>
<tr>
<td>IMM/POP</td>
<td>-0.025 (1.4)</td>
<td>-0.005 (0.3)</td>
<td>-0.027 (3.4)***</td>
<td>-0.020 (3.0)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>DIM/GDP</td>
<td>-0.004 (0.7)</td>
<td>0.008 (1.6)</td>
<td>-0.010 (2.7)***</td>
<td>-0.018 (4.3)***</td>
<td>-----</td>
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</tr>
<tr>
<td>DCA.(DIM/GDP)</td>
<td>-0.018 (3.9)***</td>
<td>-0.020 (1.9)*</td>
<td>-----</td>
<td>-----</td>
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</tr>
<tr>
<td>DUS1.(DIM/GDP)</td>
<td>-----</td>
<td>-----</td>
<td>0.008 (2.1)*</td>
<td>0.014 (4.3)***</td>
<td>-----</td>
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</tr>
<tr>
<td>PL/NPL</td>
<td>-0.039 (3.5)***</td>
<td>-0.043 (3.8)***</td>
<td>0.015 (1.3)</td>
<td>0.026 (3.5)***</td>
<td>-----</td>
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</tr>
<tr>
<td>DUS1. (PL/NPL)</td>
<td>-----</td>
<td>-----</td>
<td>-0.026 (3.9)***</td>
<td>-0.032 (7.0)***</td>
<td>-----</td>
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<tr>
<td>RMK/L</td>
<td>-0.0004 (0.8)</td>
<td>0.0006 (1.7)</td>
<td>0.0001 (0.2)</td>
<td>0.0003 (0.4)</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
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</tr>
<tr>
<td>DCA1</td>
<td>0.035 (3.8)***</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
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<tr>
<td>DCA</td>
<td>-----</td>
<td>0.055 (1.9)*</td>
<td>-----</td>
<td>-----</td>
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<tr>
<td>Trend</td>
<td>0.005 (4.2)***</td>
<td>-----</td>
<td>0.27 (6.1)***</td>
<td>0.041 (7.5)***</td>
<td>-----</td>
<td>-----</td>
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</tr>
<tr>
<td>R²</td>
<td>0.949</td>
<td>0.957</td>
<td>0.972</td>
<td>0.979</td>
<td>0.7079</td>
<td>0.7078</td>
<td>0.6201</td>
<td>0.6209</td>
</tr>
<tr>
<td>Mean-value Dep.</td>
<td>1.9</td>
<td>1.8 [=ML(2)]</td>
<td>2.0 [=ML(1)]</td>
<td>2.3 [=ML(1)]</td>
<td>31</td>
<td>32</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>N</td>
<td>4.2</td>
<td>0.52</td>
<td>1.11</td>
<td>0.92</td>
<td>0.01</td>
<td>0.69</td>
<td>0.04</td>
<td>0.70</td>
</tr>
<tr>
<td>χ²N(2)</td>
<td>.154</td>
<td>-.114</td>
<td>-.182</td>
<td>.101</td>
<td>.109</td>
<td>-.182</td>
<td>-.129</td>
<td>-.052</td>
</tr>
<tr>
<td>χ²H(1)</td>
<td>.015</td>
<td>-.005*</td>
<td>-.102</td>
<td>.101</td>
<td>-.109</td>
<td>-.182</td>
<td>-.129</td>
<td>-.052</td>
</tr>
</tbody>
</table>

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


### Table 4: Estimated Elasticity Coefficients

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>MUD</td>
<td>+.213</td>
<td>+.213</td>
<td>+.213</td>
<td>+.213</td>
<td>-.114</td>
<td>-.114</td>
<td>+.154</td>
<td>+.154</td>
</tr>
<tr>
<td>R&amp;D/GDP</td>
<td>-----</td>
<td>-----</td>
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<td>-----</td>
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<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>IMM/POP</td>
<td>-.023*</td>
<td>-.023*</td>
<td>-.023*</td>
<td>-.023*</td>
<td>-.005*</td>
<td>-.005*</td>
<td>-.009 to -.009</td>
<td>-.009 to -.009</td>
</tr>
<tr>
<td>DIM/GDP</td>
<td>-.019*</td>
<td>-.019*</td>
<td>-.019*</td>
<td>-.019*</td>
<td>+.057</td>
<td>+.057</td>
<td>-.054 to -.054</td>
<td>-.054 to -.054</td>
</tr>
<tr>
<td>PL/NPL</td>
<td>-.165</td>
<td>-.165</td>
<td>-.165</td>
<td>-.165</td>
<td>+.057</td>
<td>+.057</td>
<td>-.097</td>
<td>-.097</td>
</tr>
</tbody>
</table>

Source: Table 3. * Statistically insignificant.
The OLS estimation results are collected in Table 3. From the estimated results in Table 3 it is observed that all coefficients have a priori expected signs and they are statistically significant, with some exceptions. The estimated coefficient of RMK/L variable is not statistically significant and in one case it has wrong sign. In 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 estimated error term is behaving normally as the $\chi^2_2$ statistics shows. The values of $\chi^2_H(1)$ statistics do not indicate that homoscedasticity is problem.

Since the negative effect of imports on the wage gap is not observed for the whole sample period; therefore, 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. (see Table 4).

For comparisons, the OLS estimated coefficients are converted into elasticities around their mean values. The calculated elasticities are collected 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 two nations:

- Among the independent variables, the impact effect of union density (MUD) on the wage ratio is relatively high in Canada, while the effect of technological change (R&D/GDP) is relatively high in the U.S.
- Between two nations, the effect of imports from developing nations (DIM/GDP) on the wage gap is more pronounced in Canada.
- Between two nations, 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 but it is not statistically significant in Canada.

The inclusion of dummy variables, such as DUS and DCA, for the constant term shows that the wage gap has widened as a consequent 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 simultaneity problem between the dependent variable WP/WNP and independent variable PL/NPL in equation 1, the Nakamura and Nakamura test of the exogeneity 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:

The economic globalisation shows positive effect on the wage gap in both Canada and the U.S. The technological change and imports from developing countries have widened the wage gap in both nations. Furthermore, the labour supply variables such the deterioration of union power, the change in number of production workers, and the change in immigration ratio have negative effect on the position of unskilled workers in each nation.

There are, however, some differences between two nations:

1) In the U.S., the technological changes (R&D/GDP) have more effect on the wage gap:
   • One percentage point increase in the ratio of R&D/GDP increases the wage gap by 0.178 percentage point in the U.S compared to 0.114 percentage point in Canada.

2) In Canada, the deterioration of union power, measured by MUD variable, has more effect on the low skilled workers:
   • One percentage point decrease in MUD decreases the wage ratio by 0.213 percentage point in Canada but by 0.154 percentage point in the U.S.

3) In Canada, the change in imports from developing countries (DIM/GDP) has more effect on the wage ratio:
   • One percentage point increase in the DIM/GDP ratio decreases the wage ratio in a range of 0.054 to 0.097 percentage point in Canada but in a range of 0.006 to 0.027 percentage point in the U.S. In other words, on average the effect of imports on wage gap is four times higher in Canada.

4) The effect of immigration (IMM/POP) on the wage ratio is low in both nations:
   • One percentage point increase in the ratio of IMM/POP increases the wage ratio in a range of 0.009 to 0.013 percentage point in the U.S. and in a range of 0.005 to 0.023 percentage point in Canada, but it is statistically insignificant in the latter.

5) In Canada, the effect of a change in the share of production workers to non-production workers (PL/NPL) on the wage ratio is more pronounced:
   • One percentage point increase in the ratio of PL/NPL increases the wage gap in a range of 0.165 to 0.182 percentage point in Canada but in a range of 0.028 to 0.052 percentage point in the U.S.
### Data Appendix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
</table>
| **Dependent variable:** 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 production 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:


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


