The Relationship between Wage Inequality and International Trade: An Analysis of the Manufacturing Sector in Ontario, Saskatchewan and British Columbia in Canada

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In partial fulfillment of the requirements of the M.A. Degree
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August 2007
Ottawa, Ontario

Introduction

There is a very large economic literature studying the effect of trade on wage inequality in developed countries. The stylized facts show that there was a rapid and unanticipated growth in earnings inequality in many developed economies, such as Canada and the United States since 1970. This growth in wage inequality was associated with trade liberalization and rapid technological advances; hence some economists, such as Borjas and Ramey (1994), argued that liberalized trade and foreign competition were highly concentrated on low-skill manufacturing goods (Labour intensive), and were less intensive in high-skill manufacturing goods (Capital intensive). That consistently pushed down the low-skill workers' wages and pulled up the high-skill workers' wages.

According to Autor (2005), the wage gap experiences in OECD countries, however, were different across countries and over time, while trade with less developed countries grew steadily everywhere. This raised doubt that trade liberalization alone could account for the increasing wage gap. Paul Krugman (2000) estimated that trade with less developed countries (LDCs) was only about 2-3% of the GDP in OECD counties. In simple trade theory, if the price is set at the margin, these small trade flows would have a huge impact. However, in reality, quantity matters. Trade is too small to explain the rapidly increasing wage gap. Other economists, such as Bhagwati and Koster (1994) suggested that technological advance, not trade, was the major source of the increasing income gap. When a new innovation (which is normally a new way to substitute with China and India than Ontario.[2] British Columbia has more high skilled workers relative to China, India, and the rest of Asia. When trading with China and India, British Columbia imports manufacturing goods which require low skilled labour and exports manufacturing goods which require high skilled labour. As a result, in British Columbia, the demand for high-skilled labour should go up and the demand for low-skilled labour should go down. British Columbia's wage gap between low skilled workers and high skilled workers is forced up. Although Saskatchewan's biggest trading partner is the United States, the trade effect on Saskatchewan's wage gap between less-skilled labour and high-skilled labour is expected to be insignificant due to the fact that the province has one of best educated labour force in Canada.[3] Both the United States and Saskatchewan have an abundance of high-skilled labour abundance.

The purpose of this paper is to examine the net effect of trade on wage inequality between low skilled workers and high skilled workers in the manufacturing sector in Ontario, Saskatchewan and British Columbia in Canada. In the first section, I will discuss some empirical findings from previous studies. In the second section, the paper presents a simple theoretical labour supply model. In the third section, I specify an empirical model and analyze the data. In the fourth section, the paper will show the statistically estimated results. The final section is the conclusion.

[2] According to Ministry of Transportation's planning and strategic issues from 2007 to 2009, China, India and other Asian countries had become British Columbia's largest offshore trading partners.

[3] According to government of Canada's provincial demographics report, close to 50% of Saskatchewan's employees have a post-secondary education.

endowment line but the slope will be tilted towards the factor that is in greater demand, which leads to its price rising. It is by this mechanism that the increasing wage gap in US and Canada can be explained by the SBTC type of technological progress. Card and DiNardo (2002), however, state that a key problem for the SBTC hypothesis is that wage inequality in the United States stabilized in the 1990s despite continuing advances in computer technology. They also noticed that SBTC failed to explain the evolution of other dimensions of wage inequality, including the gender and racial wage gaps and the age gradient in the return to education. Grenier and Tavakoli (2006, a) suggested that the difference between the US and Canada was mainly due to this differences in the degree of unionization.

Grenier and Tavakoli (2006, b) also studied the evolution of Canadian earning inequality by using the time series method. They found that technical change appeared to be the most important variable explaining the increasing earning gap in Canada, which was confirmed by the finding in Grenier and Tavakoli (2006, a). They also noticed that the high level of colinearity between R&D/GDP (technological progress variable) and MUD (union density) does not allow them to disentangle the effects of those two independent variables. Instead, they included R&D and union density in different regressions. The results showed that on average a one percent increase in the R&D/GDP ratio induces the wage ratio (production worker/non production worker) decreases by 0.148 to 0.203 percent (depending on the model specification). In contrast, trade had a negative impact but relatively small impact on average, a one percent increases in NIM/GDP ratio (trade variable) leads the wage ratio to drop by 0.01 to 0.04 percent. This enforces the hypothesis that technological progress would be the major where $\rho \leqslant 1$. A_l and A_h in the production function represent the low level technology and high level technology respectively. L and H denote to the number of low-skilled and high-skilled labour respectively. From the first order condition for cost minimization, we have the following:

$$\frac{\partial Y}{\partial L} = A_l^{\rho}[A_l^{\rho} + A_h^{\rho}(\frac{H}{L})^{\rho}]^{(1-\rho)/\rho} = MPL = w_l$$

$$\frac{\partial Y}{\partial H} = A_h^{\rho}[A_h^{\rho} + A_l^{\rho}(\frac{H}{L})^{-\rho}]^{(1-\rho)/\rho} = MPH = w_h$$

For a competitive labour market, the marginal product of less-skilled (MPL) labour equals the less-skilled labour's wage, and the marginal product of high-skilled labour will equal the high-skilled labour's wage. The low-skilled wage divided by the high-skilled wage is the wage ratio called ω, where $\omega = \frac{w_l}{w_h} = (\frac{A_l}{A_h})^{\rho}[\frac{H}{L}]^{1-\rho}$.

Notice that the elasticity of substitution is $\sigma = 1/(1-\rho)$. When $\sigma \to 0$ (as $\rho \to -\infty$), there is a Leontief technology and skilled and unskilled workers are "perfect complements". When $\sigma \to \infty$ (as $\rho \to 1$), skilled and unskilled workers are "perfect substitutes". Relative supplies of each type of the worker do not affect the relative wages. So w_l / w_h will be the constant. When $\sigma \to 1$(as $\rho \to 0$) the production function is Cobb Douglas, with fixed shares payment of skilled and less skilled workers. (Autor, 2005)

It follows that

$$\therefore \quad \omega = \frac{w_l}{w_h} = (\frac{A_l}{A_h})^{\rho}[\frac{H}{L}]^{1-\rho} = (\frac{A_l}{A_h})^{\frac{\sigma-1}{\sigma}}[\frac{H}{L}]^{\frac{1}{\sigma}}$$

skilled to high skilled worker wage ratio, ω. In the other words, wage inequality increases along the decrease in MUD. Oh-Willeke (2006) found the same result that the decline of the union movement in Colorado has coincided with a sharp rise in income inequality in that state. In Colorado, the rich have gotten richer relative to the poor in the past couple of decades.[6]

∴ Union density $\uparrow \rightarrow$ $\omega \uparrow$ (prediction 4)

Under free trade and constant technology conditions, the Stolper-Samuelson theorem asserts that the domestic price ratio between the commodity that used the less abundant factor intensively and the commodity that used the abundant factor intensively will fall. Walrasian equilibrium requires that the labour market adjust accordingly to the goods market. Therefore, the price for the abundant factor will go up, while the price for the less abundant factor will go down.

∴ International Trade $\uparrow \rightarrow$ $\omega \uparrow$ for trade with developed countries

and International Trade $\uparrow \rightarrow$ $\omega \downarrow$ for trade with less developed countries

(prediction 5)

Also, Grenier and Tavakoli found that real capital stock had grown smoothly and had negative impact to widen that wage gap. However, some other research found a positive impact but insignificant. Suppose the capital enters the model. Then

∴ Capital per labour $\uparrow \rightarrow$ $\omega \downarrow$ (prediction 6)

[6] Oh-Willeke, Andrew (2006). *"Unions and Income Inequality in Colorado"*.

Due to the availability of data at the provincial level, this paper uses the time period 1981 to 2003. All data were drawn from Cansim and come from the Annual Survey of Manufactures, the Labour Force Survey, Gross Domestic Expenditure tables, immigration tables, and merchandise import and export tables. The reason this paper focuses on the manufacturing sector is that technological progress and trade affect the manufacturing sector most. The production workers in manufacturing sector are considered to be low skilled workers, and the non-production workers in manufacturing sector are considered to be high skilled workers. Please refer to appendix Table 2 for data definitions.

Table 1 of the appendix presents summary statistics of the dependent and the independent variables in the three provinces. Figure 1 presents, for Ontario, Saskatchewan and British Columbia respectively, the production labour to non-production labour wage ratios from 1981 to 2003. For the period of 1981-2003 the mean value of wage rate of low-skilled worker to wage rate of high-skilled worker ratio ($\omega = W^l/W^h$) in Ontario was 0.69 with standard deviation of 0.34. The ratio remained relatively constant until 1987, then declined smoothly to its lowest level of 0.63 in 1998, and adjusted back to about 0.70 in 2003. The mean value of the same ratio in Saskatchewan was 0.75, with standard deviation of 0.69. The wage ratio ω fluctuated around 0.8 until1992, decreased to its lowest level of 0.65 in 1996, and adjusted back to about 0.70 in 2003. For British Columbia, the mean value of the wage ratio ω was 0.76, with the standard deviation of 0.60 during the same period. The ratio ω kept just a little bit higher than 0.80 until 1987, then dropped to 0.76 and went smoothly down afterward to its lowest level of 0.65 in 1998. It adjusted back to about 0.70 in 2003.

highest level of 0.1485 in 2002.

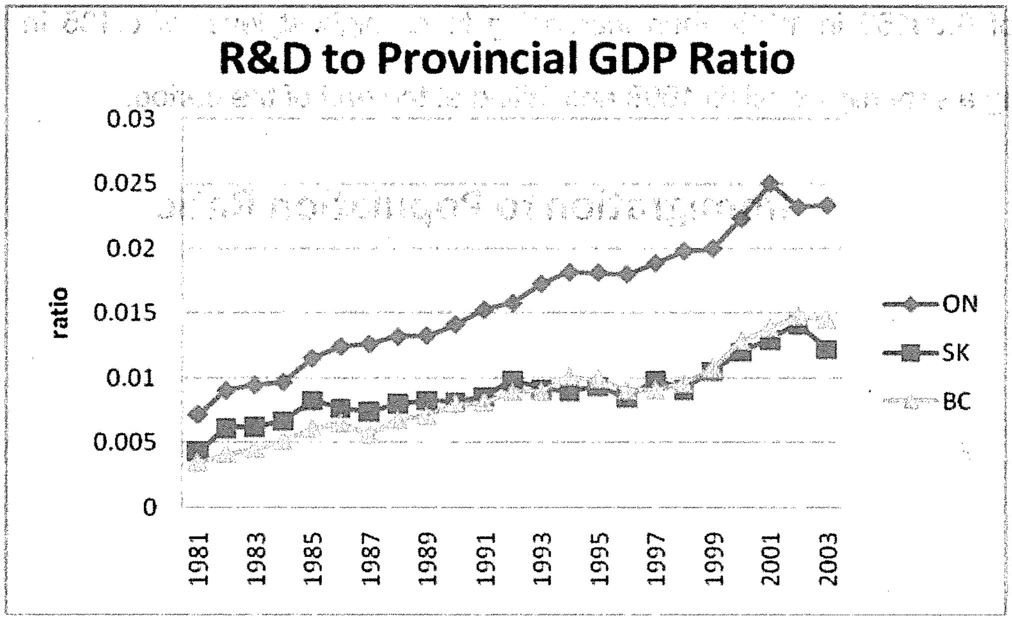

Figure 2

R&D expenditure is a small component of the GDP in all three provinces. The R&D/GDP ratios of the three provinces have the same upward trend of growth. However, Ontario had a higher proportion of its GDP invested in R&D relative to the other two provinces and kept spending more on R&D.

Figure 3 presents the immigration to population ratio in Ontario, Saskatchewan, and British Columbia. For the period of 1981-2003, the average value of the immigration to population ratio (IMM/POP) for Ontario was 0.0091 with a standard deviation of 0.00283. The ratio first decreased to its lowest level of 0.043 in 1984, grew up to its highest level of 0.137 in 1994, went down till 1999 and bounced up again. During the same period, the mean value of the IMM/POP ratio in Saskatchewan was 0.00204 with standard deviation of 0.000357. The IMM/POP ratio had slightly decreased and was almost flat with a minimum level of 0.0156 and maximum level of 0.00303. The mean value of the IMM/POP ratio for British Columbia was 0.0086 with standard deviation of 0.0028. The

The Trade/GDP ratio has a minimum level of 1.007 and a maximum level of 1.398. The average value of the Trade/GDP ratio for British Columbia was 0.894 with standard deviation of 0.555. It has a range from 0.7977 to 1.005.

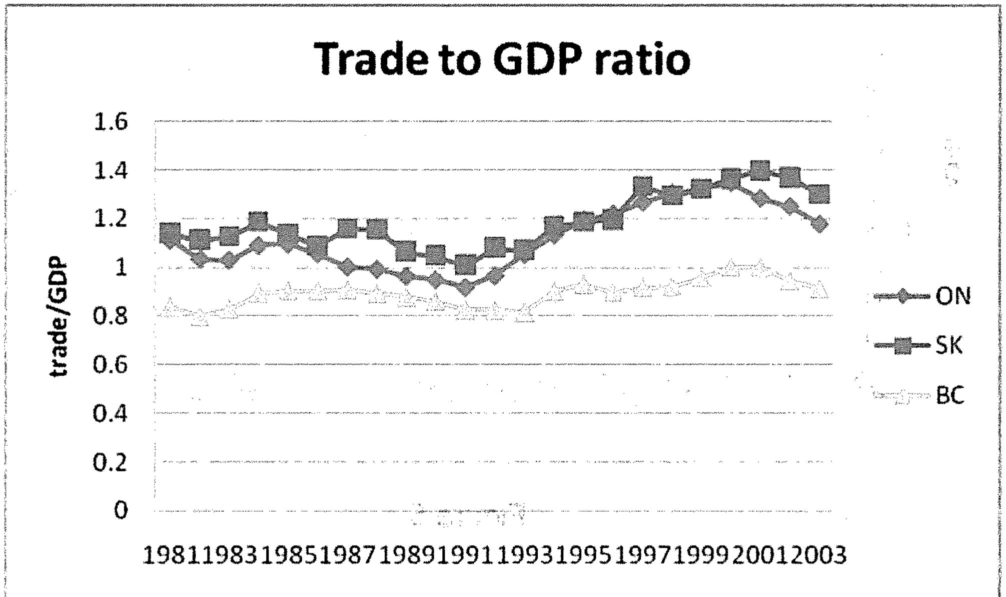

Figure 4

The striking fact is that BC's Trade/GDP ratio was smaller than that of SK. And it seems that the Asian financial crisis did not impact on the trading activities in BC, since the Trade/GDP ratio grew from 1997 to 2001. The trade/GDP ratios of the three provinces show an upward trend in the past 20 years.

Figure 5 presents manufacturing sector union density in Ontario, Saskatchewan, and British Columbia. For the period of 1981 to 2003, the mean value of the union density ratio (MUD) for Ontario was 0.306 with standard deviation of 0.016. It had a very small fluctuation between the level of 0.28 and 0.325. Meanwhile, the average value of the MUD for Saskatchewan was 0.344 and with standard deviation of 0.015. The union density ratio has a minimum level of 0.31, and a maximum level of 0.36. The average value of the union density ratio (MUD) for British Columbia was 0.385, with standard

Ontario and British Columbia suffered a set back from 1996 to 1997, but Saskatchewan experienced an increase during that periods. The ratios became much more volatile than its ratios in first decade.

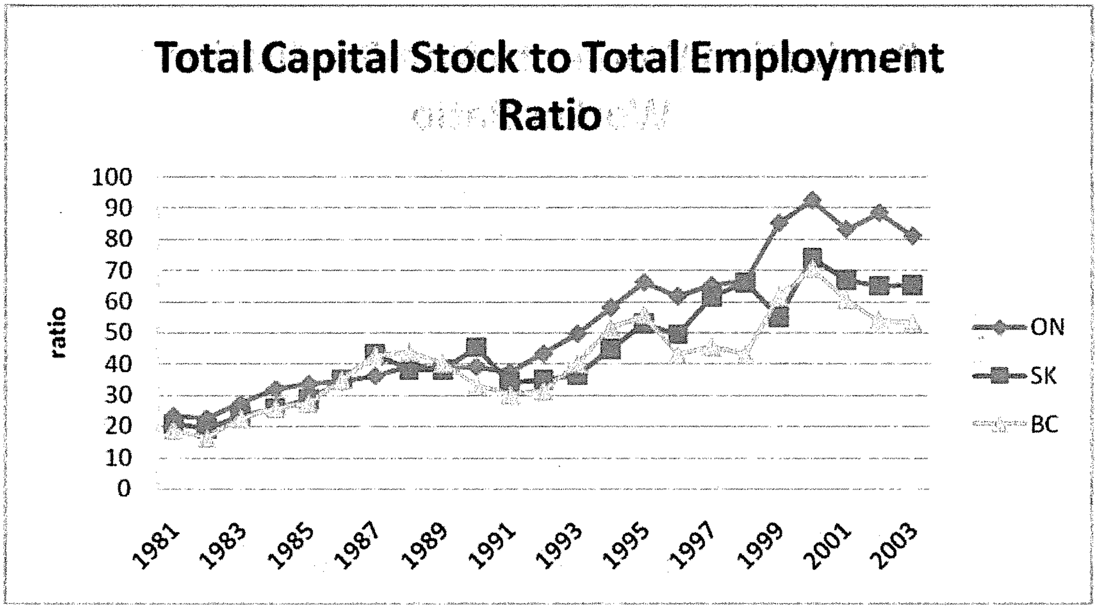

Figure 6

Figure 7 presents the ratio of the number of production workers to the number of non-production workers in Ontario, Sackatchewan, and British Columbia from 1981 to 2003. For the period of 1981-2003, the average value of the ratio (PL/NPL) of Ontario was 3.20701 with a standard deviation of 0.60. Saskatchewan's was 2.938 with a standard deviation of 0.58, and British Columbia's was 3.41 with a standard deviation of 0.52. The maximum value of Ontario's PL/NPL ratio was 4.36 in 2001. The maximum value of British Columbia's PL/NPL ratio was 4.63 in 2001. The maximum value of Saskatchewan's PL/NPL ratio was 3.92 in year 1999. The minimum ratio of Ontario of 0.0014. The ISURE model is estimated with the generalized least squares estimator because the Breusch-Pagan LM test suggests that contemporaneous correlations exist and are significant. An iterative procedure is used to obtain the feasible generalized least squares estimator of the coefficients when the disturbances' variance-covariance matrix is unknown. Initially, the regression equations of the SURE model are assumed to be unrelated, that is the correlation among contemporaneous disturbances of the model is ignored, and then, the disturbances' variance-covariance matrix is estimated based on the residuals of the estimators. At each iteration, the estimator of the ISURE model comes from the solution of a Generalized Linear Least Squares Problem. The iteration will stop until the estimates converge.[9] Table 3 presents variance-covariance matrix of three provinces' residuals from ISURE model and the Breusch-Pagan test result.

Table 4 shows the estimated results of the ISURE model. The ISURE model estimates that, in the case of Ontario, immigration and ratio of production workers to non-production workers have a negative impact on the wage ratio of production workers to non-production workers. The model also estimates that trade and union density have positive effects on the wage ratio. The above results confirm the predictions mentioned in the second section. Both effects on the wage ratio from immigration and the ratio of production workers to non-production workers are statistically significant in 5% level. The model estimates that technological progress has positive effect and the capital labour ratio has negative effect on the wage ratio, which contradicts to the theoretical prediction in the second section.

[9] Erricos J. Kontoghiorghes, (2000) *"Algorithms for solving SURE models"*, Second Conference on Numerical Analysis and Applications, University of Rousse, Rousse, Bulgaria

Before running the model with OLS, I checked for multicollinearity among the independent variables. Table 5 presents the correlation matrix of the independent variables. The correlation matrix of independent variables shows that there is high multicolinearity between R&D/GDP and RMK/L, and also between RMK/L and PL/NPL, where the correlation between R&D/GDP and RMK/L is in excess of 0.8 level and the correlation between RMK/L and PL/NPL is very closed to 0.8 level, at 0.78.[10] I dropped the RMK/L and added three interaction trade dummy variables to the ordinary least square regression. Table 6 shows the estimated results of the OLS model. Most of estimated coefficients are statistically insignificant, and the signs of trade Ontario-dummy interaction and trade British Columbia-dummy interaction are contrary to the theoretical prediction.

Another model for panel data is the fixed effect model. Table 7 presents the estimated results of the fixed effects model. However, that kinds of model is useful in the context of large cross-section and short period, which is not the case in this paper. Most of estimated coefficients are statistically insignificant. Even though trade Ontario-dummy interaction's coefficient confirms the theoretical prediction, a positive sign and statistically significant trade British Columbia-dummy interaction's coefficient is contrary to the theoretical prediction.

Compared to the pooled OLS model and the fixed effects model, the ISURE model is a better model when n, the number of cross-sections is small and t, the number of periods in each cross-section is large, without dropping any independent variable and allows analyzing the effect of trade on the wage ratio in different provinces directly.

[10] Correlation 0.8 or higher is considered to be very high implicates the existence of multicolinearity.

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Table 2: The source of the data

Variable	Source
Dependent variable: Average wage of production workers divided by average wage of non-production workers in Canadian manufacturing	Annual Survey of Manufactures. Cansim II table 301-0001 and 301-0003 together cover the period 1981-2003.
Independent Variables:	
Research and development expenditures as a proportion of GDP	Cansim II table 358-0001 for R&D and table 384-0002 for provincial GDP
Total immigration divided by population	Cansim II table 051-0011 for immigration and table 051-0001 for population
Total trade volume divided by GDP	Cansim II table 384-0002
Manufacturing union density	Cansim II tables 282-0078, 279-0028, and 279-0027.
Manufacturing capital stock divided by number of production workers	Cansim tables 301-0001, and 301-0003.

Table 4: Technological progress, Immigration, Trade, Union, Capital stock per labour, and production and non-production workers ratio effects on wage ratio ω : Ontario, Saskatchewan and British Columbia manufacturing sectors (1981-2003)

(ISURE MODEL)

		Coefficient	Std.Dev.	Pr.
Ontario	R&D/GDP	0.8503	1.6777	0.615
	imm/pop	-2.9211**	1.3308	0.033
	Trade/GDP	0.0408	0.0386	0.296
	MUD	0.0635	0.2381	0.791
	RMK/L	-0.0004	0.0004	0.315
	PL/NPL	-0.0409***	0.0097	0.000
Saskatchewan	R&D/GDP	2.7193	2.8229	0.340
	imm/pop	-1.0070	13.1625	0.939
	Trade/GDP	0.0233	0.0559	0.679
	MUD	-0.3181	0.3285	0.338
	RMK/L	0.0008	0.0005	0.113
	PL/NPL	-0.1388***	0.0126	0.000
British Columbia	R&D/GDP	-2.7440	2.4639	0.271
	imm/pop	-5.4988***	1.7556	0.003
	Trade/GDP	-0.2264*	0.1248	0.076
	MUD	-0.0177	0.2379	0.941
	RMK/L	-0.0013**	0.0006	0.037
	PL/NPL	-0.0260*	0.0145	0.078

Note: *, **, and *** indicate 10%, 5% and 1% statistically significant levels, respectively.

Table 6: Technological progress, Immigration, Trade, Union, Capital stock per labour, and production and non-production workers ratio effects on wage ratio ω : Ontario, Saskatchewan and British Columbia manufacturing sectors (1981-2003)

(OLS MODEL)

	Coefficient	Std.Dev.	Pr.
R&D/GDP	1.6019	1.8908	0.400
imm/pop	-2.0939	1.9500	0.287
Trade/GDP	0.0287	0.0527	0.589
MUD	0.0782	0.1808	0.667
RMK/L	Dropped Due to multicollinearity		
PL/NPL	-0.0972***	0.0126	0.000
Trade Ontario- Dummy interation (io)	-0.0175	0.0131	0.187
Trade Saskatchewan-Dummy interation (is)	-0.0857***	0.0236	0.001
Trade British Columbia-Dummy interation(ib)	0.0857***	0.0236	0.001
Constant term	0.9617***	0.0818	0.000

Note: *, **, and *** indicate 10%, 5% and 1% statistically significant levels, respectively.

$R^2 = 0.8246$, Adj $R^2 = 0.8044$