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John M. Curtis and Aaron Sydor

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Foreword

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Cat: IT5-1/2006E

ISBN: 0-662-43036-0

(Publié également en Français)

The Effect of Trade on Productivity Growth and the Demand for Skilled Workers in Canada

Wulong Gu
Statistics Canada

&

Lori Whewell Rennison
Department of Finance

Introduction

The last two decades have witnessed growing trade integration between Canadian industries and those in the United States and elsewhere. The ratio of exports to gross domestic product in the Canadian business sector rose from 35.3 percent in 1981 to 52.6 percent in 1997, while the ratio of imports to gross domestic product increased from 37.2 percent to 51.3 percent. Most of the increase in trade integration occurred in the 1990s after two major policy developments: the implementation of the Canada-U.S. Free Trade Agreement (FTA) in 1989, which led to the gradual removal of trade barriers between Canada and the United States, and the North American Free Trade Agreement (NAFTA) in 1994, which expanded the free trade area to Mexico.

In this paper, we examine the implications of this marked increase in trade integration on productivity and the demand for skilled workers in Canada over the past two decades. Increased trade integration institutionalized and expanded by the FTA were expected to significantly improve Canadian productivity — as industries benefited from further specialization and economies of scale and as resources were reallocated to more efficient industrial pursuits. Similarly, the increased volume of international trade with low-wage countries was expected to increase the demand for skilled workers relative to unskilled workers as the production of less skill-intensive goods shift to the low-wage countries. In this study, we examine the extent to which these effects have taken place.

To examine the effect of trade integration on productivity growth, this study departs from most previous empirical studies. Typically, empirical studies on trade and productivity capture only the productivity impacts on export and import industries. However, trade integration affects more than just the productivity of industries directly involved in trade. It also affects supplier industries. To properly assess the impact of trade integration on productivity growth requires the analysis of productivity impacts at all stages of production. For this reason, we use the effective rate of productivity growth to examine the relationship between trade integration and productivity growth.

* We would like to thank John Baldwin, Gary Sawchuk and an anonymous referee for their helpful comments. This paper reflects the views of the authors and not those of Statistics Canada or of the Department of Finance.

The effective rate of productivity growth in exports and imports captures the direct productivity gains of sectors involved in trade as well as those associated with industries that supply intermediate inputs to export and import industries. The concept of an effective rate of productivity was introduced by Sraffa (1960) and has been used by Rymes (1972), Hulten (1978), and Wolff (2003). De Juan and Febrero (2000) argue for the use of the effective rate of total factor productivity growth to better measure competitiveness.

To examine Canada's comparative advantage in international trade and the effect of trade on the demand for skilled workers, we follow the factor content of trade approach. We use an input-output model to determine how much skilled and unskilled labour Canada uses in producing its exports, and how much labour would have been used had its imports been produced in Canada. The difference between the skilled and unskilled labour content of exports and imports provides a measure of the impact of trade on the demand for skilled and unskilled workers.

The share of skilled workers in Canada's exports relative to that in imports also sheds light on where Canada's comparative advantage lies in international trade. According to the Heckscher-Ohlin-Vanek model, trade specialization and comparative advantage result from relative factor abundance (Vanek, 1968; Deardorff, 1982). A country will export products that use intensively those factors in which it is relatively abundant and import those products that use intensively those factors in which it is relatively scarce. It is thus believed that Canada has a comparative advantage in goods and services intensive in natural resources. However, Canada also has the highest share of workers with post-secondary education among the OECD countries (OECD, 2004). The share of Canadians with a university degree is below that of the U.S., its major trading partner, but Canada exceeds all other countries once other forms of post-secondary education are included. Thus, human capital might also be expected to be a growing source of Canada's comparative advantage.

Review of Previous Empirical Literature

A large number of studies have examined the effect of trade on productivity growth. The studies using aggregate data demonstrate that access to foreign intermediate inputs and capital goods through imports is associated with higher productivity (e.g., Eaton and Kortum, 2001; Gera, Gu and Lee, 1999). This evidence supports the view that imports act as a conduit for knowledge transfer across countries. However, most of these studies focus on imports and use the black-box approach that relies on aggregate data.

A number of recent empirical studies use micro data to examine the effect of exports on productivity growth. These studies provide mixed evidence. While Bernard and Jensen (2004) find that there is little to suggest that exports have a positive effect on productivity growth in U.S manufacturing plants, Baldwin and Gu (2001, 2004), however, show that exports lead to productivity improvements in Canadian manufacturing plants.

A number of studies in Canada have examined the effect of trade liberalization and increased trade integration on productivity growth (Trefler, 2004; Baldwin, Caves and Gu, 2005). Trefler (2004) finds that the Canada-U.S. FTA increased labour productivity in the Canadian manufacturing sector. He

shows that those industries with the largest tariff cuts experienced the greatest increases in labour productivity growth during the post-FTA period. Baldwin, Gu and Caves (2005) show that Canadian plants became more specialized in output as a result of trade liberalization. The increased product specialization and the exploitation of scale economies are an important source of productivity gains from the FTA.

The issue of whether increased trade with low-wage countries has hurt unskilled workers has become a topical area of research in Canada and other developed countries. Wood (1991) argues that increased trade with developing countries is the main cause of the widening wage gap between skilled and unskilled workers in developed countries. Sachs and Shatz (1996) conclude that trade with developing countries has reduced the demand for unskilled workers. In a survey of empirical evidence, Baldwin (1995) finds that domestic factors have been much more important in accounting for changes in total employment in Canada than changes in the demand for imports. However, he concludes that increased imports were a major factor in accounting for employment declines in such low-technology industries as textiles, clothing, footwear, wood and furniture.

Regarding skills and human capital as a source of comparative advantage for developed countries, Lee and Schluter (1999) use an input-output model and occupational data to estimate the skill content of U.S. trade over the period 1972-1992. They find that the ratio of high-skilled to low-skilled workers was greater for exports than for imports, although the difference between the ratios was unchanged over the period. Moreover, the difference between the skilled and unskilled employment content of exports and imports was quite small suggesting that trade was not a contributing factor to changes in the demand for skilled and unskilled workers in the U.S.

Wolff (2003) also examined skill content and comparative advantage in U.S. international trade for the period 1947-1996 using input-output data and an occupation-based measure of skill. He finds that U.S. exports have a high content in cognitive and interactive skills relative to imports, and a low content in motor skills. In contrast to Lee and Schulter (1999), the analysis shows that the skill gap between exports and imports has widened over time, primarily due to changes in the composition of U.S. exports and imports. The results suggest that the U.S. comparative advantage in international trade lies in cognitive and interactive skill-intensive products, and the comparative advantage in cognitive and interactive skills increased over time. Wolff (2003) further found that imports are more capital-intensive and R&D-intensive than exports. However, in the case of capital intensity, he finds that the difference has decreased over time. This suggests that there has been a gradual shifting of U.S. comparative advantage toward capital-intensive goods.

Webster (1993) looked at the skill content and comparative advantage in U.K. international trade. He found that the U.K. tended to export goods and services that are intensive in non-manual skills (professional occupations). This indicates that skills and broad levels of human capital are an important source of the UK's comparative advantage. Driver et al. (2001) used an input-output model to examine the effect on employment of various changes in trade structure in the U.K. They found that radical changes in the U.K. trade pattern (e.g. adopting the

trade pattern of West Germany) would lead to large employment gains. Engelbrecht (1996) estimated the skill content of German exports and imports in 1976, 1980 and 1984. In contrast to the evidence for the U.K (Webster, 1993), he concluded that comparative advantage for Germany resulted more from specialization in particular skill types than from the overall level of human capital. Germany tended to export goods and services intensive in skilled manual occupations.[1]

While there is a considerable empirical literature for the U.S. and other countries, there is little recent empirical evidence on the skill content and comparative advantage in Canada's international trade. This paper provides such evidence.

Methodology

Our method for calculating the factor content of trade is based on an input-output model. The method dates back to the work of Leontief (1956, 1964) and continues to be a standard method for examining the factor content and comparative advantage in international trade (Wolff, 2003; Webster, 1993; and Hans-Jurgen, 1996). In this section, we first present the method for estimating the factor content of Canadian exports and imports. The method is based on the total (direct plus indirect) factor requirements of exports and of the domestic substitutes for imports. We then use the total factor requirements of exports and imports to calculate the effective rate of partial factor and total factor productivity in export and import industries.

The starting point for the construction of the factor content of trade is the fundamental input-output relationship:

(1) $$X = BX + C + E - M \ .$$

The column vector $X = \lfloor X_j \rfloor_{N\times 1}$ represents the gross output of industry j, where N denotes the number of industries. The input-output matrix $B = \lfloor b_{ij} \rfloor_{N\times N}$ denotes the quantity of goods in industry i used in the manufacturing of one unit of output in industry j. The vector $C = \lfloor C_j \rfloor_{N\times 1}$ is domestic consumption of the output of industry j and includes personal consumption, fixed investment and government consumption. Industry exports and imports are shown by the export and import vectors $E = \lfloor E_j \rfloor_{N\times 1}$ and $M = \lfloor M_j \rfloor_{N\times 1}$.

In equation (1), column vector BX is the intermediate input demand for an industry's output. The remaining terms on the right-hand side are the final domestic demand for the industry output.

To determine the gross output of Canadian industries for a given level of final demand, we take into consideration "import leakages." These are leakages from final demand that occur when some final demand is met from imports

[1] A number of studies have also estimated the factor content of trade for emerging economies (e.g. Ohno, 1988).

instead of domestic production. To do so, we assume that imports of an industry are proportional to domestic production less exports:[2]

(2) $M = m(X - E)$.

A typical element m_j of the diagonal matrix $m = diag(m_j)$ gives the ratio of imports to domestic production net of exports in industry j.

Therefore, equation (1) may be re-written as

(3) $X = BX + C + E - m(X - E)$.

Solving for gross output X, we have:

(4) $X = (I - B + m)^{-1}(C + (1 + m)E)$,

where I is an identity matrix. X in Equation (4) is the gross output levels that are required to satisfy final demand. Let us define:

$k = [k_1, k_2, ..., k_N]$ = row vector of capital coefficients, where k_j is total capital per unit of output in industry *j*,

$l = [l_1, l_2, ..., l_N]$ = row vector of labour coefficients, where l_j is the total labour per unit of output,

$s = [s_1, s_2, ..., s_N]$ = row vector showing natural-resource intermediate inputs per unit of output,

$w = [w_1, w_2, ..., w_N]$ = row vector showing labour compensation in 1992 dollars per unit of output.

The total capital, labour and natural resource content of final demand is calculated as:

(5) $K = k(I - B + m)^{-1}(C + (1 + m)E)$,

(6) $L = l(I - B + m)^{-1}(C + (1 + m)E)$, and

(7) $S = s(I - B + m)^{-1}(C + (1 + m)E)$.

The total labour compensation in final demand is calculated as:

(8) $W = w(I - B + m)^{-1}(C + (1 + m)E)$

On the basis of the total capital and labour contents in exports, we can estimate the effective rate of capital and labour productivity in export industries. The effective rate of capital productivity in exports is defined as output per unit of total capital requirements in exports. It is given by

[2] Previous studied have used alternative assumptions about imports. Lahr (2001) and Jackson (1998) assumed that imports are proportional to the sum of domestic production and net imports. St. Louis (1989) assumed that imports are proportional to the sum of domestic production and total imports. We have used these two alternative assumptions about imports in our empirical analysis. Our findings on the sources of comparative advantage and the effect of trade on productivity and the demand for skilled workers are robust to these alternative assumptions.

$E/\left[k\left(I-B+m\right)^{-1}\left((1+m)E\right)\right]$. The effective rate of labour productivity in exports is defined as output per unit of total labour requirements in exports, and is given by $E/\left[l\left(I-B+m\right)^{-1}\left((1+m)E\right)\right]$. The effective rate of total factor productivity in exports is calculated as a weighted sum of capital and labour productivity using the share of capital and labour in total income as weights.[3]

To examine the comparative advantage in Canada's international trade, we need to calculate the factor content of imports. To do so, we require the input-output matrices of the import-producing countries. However, those matrices are not available. As in most previous studies, we instead use the Canadian input-output matrices to estimate the factor content of Canadian imports. The estimated factor content of Canadian imports thus measure how much capital and labour would have been required if the imported goods had been produced in Canada.

Data

The data for the analysis consist of input-output tables, capital stock and labour inputs from Statistics Canada. The original input-output tables are 147-sector input-output tables in nominal dollars for the years 1981, 1989 and 1997. The tables are aggregated to 123 business sector industries to be consistent with the industry aggregation for data on capital and labour inputs. We have chosen those three years so as to compare the factor content of trade and productivity growth between pre-FTA period 1981-1989 and post-FTA period 1989-1997.

Capital stock figures represent net capital stock in 1992 dollars, start-of-year estimates. It is calculated using a perpetual inventory method and geometric depreciation pattern (for details, see Statistics Canada, 1994). Data on the labour input include hours worked and labour compensation at the 123 industries of the business sector. They are derived from the labour input database in the Statistics Canada productivity account (see, Gu et al., 2003). The data base classifies workers by four educational attainment levels: 0-8 years of schooling, high school, post-secondary and university or above. We will use this classification to measure the skill content of Canada's international trade.

The Composition of Canada's international trade

The percentage composition of Canada's exports and imports is shown in Tables 1A and 1B. In general, Canada's international trade has been shifting away from primary industries toward manufacturing and services over the past several decades. Manufacturing increased from 65% of total exports in 1981 to 71% by 1997, as services' share rose from 14% to 18%. As a result, the share of exports in primary industries fell from 21% to 11%. Similar shifts were observed in imports.

[3] For the remainder of the paper, all references to productivity rates refer to effective rates.

Table 1A: Percentage Composition of Canadian Exports

	1981	1989	1997	Change, 1981-1997
Primary	20.72	13.32	11.43	-9.30
Manufacturing	65.11	70.89	70.93	5.82
Services	14.17	15.78	17.65	3.48
By detailed industry (ranked by change over 1981-97)				
Transportation equipment	17.41	24.42	23.47	6.06
Electrical & electronic products	3.36	5.34	6.63	3.27
Business services	1.56	1.99	3.10	1.54
Wholesale	2.33	3.15	3.69	1.36
Wood	4.00	4.12	5.24	1.24
Chemical & chemical products	3.20	3.45	4.14	0.94
Plastic	0.41	0.68	1.21	0.80
Finance & insurance	1.44	2.25	2.21	0.77
Furniture & fixtures	0.35	0.53	0.84	0.49
Clothing	0.43	0.44	0.81	0.39
Rubber	0.61	0.77	0.93	0.32
Printing & publishing	0.27	0.46	0.54	0.27
Primary textile	0.35	0.35	0.62	0.27
Textile products	0.19	0.27	0.36	0.17
Retail	0.08	0.16	0.20	0.12
Non-metallic mineral products	0.57	0.75	0.68	0.11
Other services	3.38	3.72	3.46	0.08
Transportation services	3.59	3.13	3.64	0.05
Leather & allied products	0.14	0.14	0.16	0.01
Construction	0.03	0.03	0.01	-0.02
Tobacco	0.16	0.09	0.10	-0.06
Fabricated metal	3.00	2.32	2.93	-0.07
Fishing, logging & forestry	0.35	0.29	0.25	-0.10
Beverage	0.42	0.32	0.32	-0.10
Other manufacturing	1.96	1.69	1.70	-0.25
Communication & other utilities	1.76	1.37	1.35	-0.41
Machinery	3.73	2.71	3.29	-0.45
Food	4.22	3.42	3.61	-0.61
Refined petroleum & coal	2.29	1.26	1.27	-1.02
Crude petroleum & natural gas	7.50	4.88	5.47	-2.04
Primary metal	8.80	8.32	5.89	-2.92
Paper & allied products	9.22	9.04	6.17	-3.05
Agriculture & related services	6.36	2.98	3.03	-3.33
Metal mines & other mines	6.51	5.18	2.67	-3.83

Table 1B: Percentage Composition of Canadian Imports

	1981	1989	1997	Change, 1981-1997
Primary	14.22	6.08	5.19	-9.03
Manufacturing	72.80	78.74	79.07	6.27
Services	12.98	15.17	15.74	2.76
By detailed industry (ranked by change over 1981-97)				
Electrical & electronic products	8.49	12.51	13.58	5.09
Transportation equipment	19.87	22.91	21.83	1.97
Chemical & chemical products	4.38	4.84	6.22	1.84
Finance & insurance	2.14	3.08	3.29	1.15
Communication & other utils.	0.51	1.22	1.29	0.78
Plastic	1.02	1.44	1.50	0.49
Other services	4.20	4.96	4.68	0.48
Business services	2.71	2.75	3.10	0.38
Clothing	1.46	2.23	1.82	0.36
Paper & allied products	1.46	1.56	1.76	0.31
Rubber	0.85	1.08	1.15	0.30
Printing & publishing	1.07	1.67	1.35	0.29
Food	2.99	2.92	3.05	0.06
Textile products	0.81	0.77	0.86	0.05
Furniture & fixtures	0.59	0.82	0.64	0.05
Tobacco	0.07	0.10	0.12	0.04
Wood	0.71	0.66	0.75	0.03
Transportation services	2.36	2.13	2.39	0.03
Wholesale	0.89	0.88	0.91	0.02
Beverage	0.33	0.33	0.31	-0.02
Retail	0.12	0.11	0.09	-0.04
Construction	0.05	0.04	0.01	-0.04
Leather & allied products	0.85	1.04	0.76	-0.09
Fishing, logging & forestry	0.36	0.23	0.25	-0.11
Non-metallic mineral products	1.16	1.33	1.03	-0.13
Refined petroleum & coal	1.24	1.46	1.04	-0.19
Fabricated metal	5.18	4.22	4.97	-0.21
Primary textile	1.55	1.27	1.12	-0.43
Other manufacturing	4.25	3.80	3.66	-0.58
Agriculture & related services	1.97	1.42	1.12	-0.85
Primary metal	5.53	4.17	4.34	-1.19
Metal mines & other mines	2.82	1.98	1.27	-1.55
Machinery	8.96	7.58	7.22	-1.75
Crude petroleum & natural gas	9.06	2.45	2.54	-6.52

Transportation equipment was the most important traded good in Canada over the 1981 to 1997 period by a large margin, accounting for more than 20% of both exports and imports. Moreover, its share of exports increased by more than

any other industry over the period. While four of the top five leading Canadian exports in 1981 were also among the top five in 1997 (transportation equipment, 23%; paper and allied products, 6.1%; primary metals, 5.9%; and crude petroleum and natural gas, 5.5%), there were two notable shifts over the period. First, the biggest gains (after transportation equipment) were made by electrical and electronic equipment, from 3.4% to 6.6%, becoming one of Canada's top five exports by 1989. Business services, wholesale, and wood industries also increased their share of total exports by more than a percentage point over the 1981-1997 period. Second, mining and agricultural industries were among the leading exports in 1981 but have steadily declined in importance, losing approximately half of their share of total exports by 1997. Mining industries fell from 6.5% to 2.7%, while agriculture and related services dropped from 6.4% to 3%. Other industries which lost significant share over the period included crude petroleum and natural gas, primary metals and paper and allied products. Nevertheless, these three industries remained among the most important Canadian exports in 1997.

Turning to imports, the leading imports in 1997 after transportation equipment (21.8%) were electrical and electronic equipment (13.6%), machinery (7.2%), and chemicals and chemical products (6.2%). Electrical and electronic products made the biggest gains, growing from 8.5% of total imports in 1981 to 13.6% in 1997. Significant gains were also made in chemicals and chemical products and in finance and insurance. The industry that lost the largest share over the period was crude petroleum and natural gas, as imports fell from 9.1% in 1981 to 2.5% in 1997 (with the shift occurring between 1981 and 1989).

In summary, the composition of Canada's international trade, in the period under review, has shifted away from primary industries toward manufacturing and services. The auto sector accounted for the largest share of Canadian exports and imports throughout the 1981 to 1997 period, and the electrical and electronic products industry became an increasingly important part of both Canada's exports and imports. The change in export and import composition was similar across the period; the correlation between 1981 and 1997 export and import shares is 0.94 and 0.93 respectively.

Skill Composition of Canada's Exports and Imports

Based on the methodology described in Section 3, we now examine the factor content of Canadian exports and imports. The results for skill composition, shown in Table 2, are a bit surprising. Based on our measure of skills (educational attainment), the data suggest that human capital is not a source of comparative advantage in Canada's international trade. Rather, skill composition over the period 1981-1997 is similar for exports, imports and the total business sector. In particular, Canadian exports were not more skill-intensive than Canadian imports over this period. For instance, in 1997, the share of workers with bachelor degrees or above in exports was 15 percent, and the share of those workers in imports was 16 percent. When we include those workers with other types of post-secondary tertiary education, we find that that the share of more educated workers in exports was 56 percent, compared with 57 percent in imports.

Moreover, the share of workers with some form of post-secondary education in Canadian exports and imports showed similar increases over the 1981-1997 period, those in exports increased from 39 percent to 56 percent, and in imports increased from 41 percent to 57 percent.

Table 2: Skill Content of Canadian Exports and Imports

	1981	1989	1997	Change, 1981-1997
	A. Share of hours with less than high school (%)			
Exports	16.26	10.49	6.09	-10.18
Imports	14.67	10.02	5.69	-8.98
Difference	1.60	0.47	0.40	
Business Sector	14.27	9.09	5.13	-9.14
	B. Share of hours with high school (%)			
Exports	45.00	44.69	37.72	-7.27
Imports	44.40	44.27	36.94	-7.46
Difference	0.60	0.43	0.79	
Business Sector	46.30	44.85	37.06	-9.24
	C. Share of hours with post-secondary education (%)			
Exports	30.70	34.01	41.00	10.30
Imports	31.90	34.33	41.58	9.69
Difference	-1.20	-0.32	-0.59	
Business Sector	31.38	35.15	42.63	11.25
	D. Share of hours with university or above (%)			
Exports	8.04	10.80	15.19	7.15
Imports	9.04	11.37	15.79	6.75
Difference	-1.00	-0.57	-0.60	
Business Sector	8.05	10.91	15.18	7.14

The results stand in sharp contrast to those reported in similar studies for the U.S. and the U.K. where skills and human capital are identified as sources of comparative advantage (Lee and Schulter, 1999; Wolff, 2003; Webster, 1993), in the case of the U.S. the comparative advantage in skill-intensive industries increased over time (Wolff, 2003). However, there are several things to bear in mind in interpreting these results. First, other studies measure skills based on occupation rather than on educational levels as we do in this paper. For example, Wolff (2003) uses occupation data which allows him to distinguish between substantial complexity, interactive and motor skills – these results need not be the same as those based on education levels which have been rising among workers in all sectors over the past two decades. Indeed, when Wolff (2003) measures skills by mean educational attainment he finds that the U.S. comparative advantage in skill-intensive industries has been constant since 1950, contrary to his results based on occupational data. Wolff suggests that this might be explained by the

fact that schooling levels among the United States' trading partners have increased faster than the cognitive skill content of their exports to the United States.

Second, the composition of Canada's international trade is different from that in the United States, and has evolved differently over time. While Canada's exports have been shifting away from natural resources toward manufacturing and services, primary industries continue to represent a larger share of Canada's exports than in the United States. The share of workers with post-secondary education in hours worked tend to be lower in these industries – 42% versus 67% for manufacturing industries such as electrical and electronic products which comprise a larger share of U.S. exports. Moreover, less knowledge-intensive industries such as clothing and textile products represent a larger share of U.S. imports than Canadian imports, which lowers the skill content of their imports relative to their exports.

Despite these differences, the finding that Canada has a comparative disadvantage in skills may simply reflect the fact that Canada has a smaller pool of workers with a university degree. Despite the larger share of those with other forms of post-secondary education in Canada, the U.S. studies may be capturing skills that require university education in specific knowledge fields which are less prevalent in Canada. In this sense, it wouldn't be surprising that the U.S. has a comparative advantage in skills while Canada does not; rather, it would be consistent with the view that comparative advantage stems from relative factor abundance.

Capital Intensity of Canada's Exports and Imports

Panel A of Table 3 shows the capital intensity of Canadian exports and imports. The results show that Canadian exports were more capital intensive than were Canadian imports over the period 1981-1997. In 1997, the capital intensity of Canadian exports was 53 percent higher than that of Canadian imports. This suggests that the comparative advantage in Canada's international trade has been in capital-intensive industries, and that capital is a source of comparative advantage for Canada.

It must be noted, however, that over the period 1989-1997, the capital intensity of exports relative to imports declined from 1.7 to 1.5. This indicates a gradual shifting of Canada's comparative advantage away from capital-intensive goods and services in the 1990s. For the period 1981-1989, there was little change in the relative capital intensity of exports and imports.

Panels B, C and D of Table 3 show results for total net capital stock of equipment and structures per hour worked. We find that Canada tended to export goods and services that were more intensive in both equipment capital and structure capital. This means that equipment capital and structure capital are sources of comparative advantage for Canada. In 1997, the capital intensity of exports relative to imports was 1.5 for equipment capital, 1.1 for building structure, and 1.7 for engineering structure.

While Canada's comparative advantage in capital-intensive industries declined in the 1990s, comparative advantage in engineering structure capital increased during the period. The results in Panel D of Table 3 show that the

engineering-structure intensity of exports relative to imports increased from 1.70 to 1.74 during the period 1989-1997.

Table 3: Capital Intensity of Canadian Exports and Imports

	1981	1989	1997	Ratio of 1997 to 1981
	A. Total capital (in 1992 dollar) per hour worked			
Exports	65.80	74.41	75.06	1.14
Imports	48.72	51.19	53.75	1.10
Ratio	1.71	1.72	1.53	
Business Sector	38.45	43.17	49.02	1.27
	B. M&E capital (in 1992 dollar) per hour worked			
Exports	17.86	20.52	21.00	1.18
Imports	12.97	15.22	17.03	1.31
Ratio	1.80	1.77	1.52	
Business Sector	9.91	11.61	13.80	1.39
	C. Building structure capital (in 1992 dollar) per hour worked			
Exports	15.33	17.33	17.70	1.15
Imports	12.92	14.44	15.87	1.23
Ratio	1.19	1.20	1.12	
Business Sector	11.30	13.04	14.89	1.32
	D. Engineering structure capital (in 1992 dollar) per hour worked			
Exports	32.61	36.56	36.35	1.11
Imports	22.82	21.52	20.85	0.91
Ratio	1.43	1.70	1.74	
Business Sector	17.24	18.52	20.33	1.18

Our results are consistent with the results for Canada of ten Raa and Mohnen (2001), who suggest that Canadian exports were more capital intensive than imports and Canada was a net exporter of capital service (Table 2 in ten Raan and Mohnen, 2001). These results for Canada differ from the results for the U.S. reported in Wolff (2003). He found that U.S. exports are less capital-intensive than U.S. imports over the period 1947-1996. This suggests that while capital is a source of comparative advantage for Canada, it is source of comparative disadvantage for the U.S. However, there was a gradual shifting of U.S. comparative advantage back toward capital-intensive goods and services over the period 1977-1996. Over that period, Wolff (203) finds that the capital intensity of U.S. exports relative to U.S. imports increased from 0.67 to 0.91.

Natural Resource Intensity

We have classified natural resources into: (1) agriculture, forestry and fishery products, (2) metal mines and other mines and (3) crude petroleum and natural gas. Webster (1993) and Hans-Jurgen (1996) used a similar classification in their natural-resource content of trade calculation for the U.K. and Germany. It

is widely believed that Canada's comparative advantage in international trade lies in natural-resource-intensive industries. Canada tends to export goods and services that are intensive in natural resources and import goods and services that are less intensive in natural resources.

The results in Table 4 confirm this view. We find that Canadian exports have higher natural-resource content per unit of output than Canadian imports. All three types of natural resources are a source of comparative advantage for Canada. In 1997, the ratio of natural-resource content in exports relative to imports was 1.5 for agriculture, forestry and fishery products, 1.4 for metal mines and other mines and 1.2 for crude petroleum and natural gas.

There was a decline in Canada's comparative advantage in agriculture, forestry and fishery products and crude petroleum and natural gas over the period 1981-1997. On the other hand, Canada's comparative advantage in metal mines and other mines showed little change. Over the period 1981-1997, the ratio of natural-resource content in exports relative to imports declined from 1.8 to 1.5 for agriculture, forestry and fishery products. The ratio declined from 1.4 in 1981 to 1.2 in 1997 for crude petroleum and natural gas, and remained unchanged for metal mines and other mines.

Table 4: Natural Resource Intensity of Canadian Exports and Imports

	1981	1989	1997	Ratio of 1997 to 1981
	A. Agriculture, forestry and fisheries			
Exports	0.060	0.042	0.041	0.684
Imports	0.033	0.030	0.027	0.823
Ratio	1.818	1.425	1.512	
Business Sector	0.054	0.040	0.041	0.765
	B. Metal mines and other mines			
Exports	0.060	0.055	0.032	0.532
Imports	0.040	0.032	0.022	0.553
Ratio	1.488	1.747	1.432	
Business Sector	0.040	0.032	0.022	0.553
	C. Crude petroleum and natural gas			
Exports	0.087	0.038	0.034	0.394
Imports	0.062	0.035	0.029	0.473
Ratio	1.412	1.080	1.175	
Business Sector	0.034	0.020	0.025	0.728

Wages and Productivity of Exports and Imports

Panel A of Table 5 shows that average wages in export industries were similar to those in import industries. Over the period 1981-1997, wages in export industries relative to import industries showed little change. Panel B of Table 5 shows that the level of labour productivity (defined as value added per hour) in export and import industries was also similar during the period. This suggests that the average labour costs (defined as the ratio of real wages to labour productivity) in exports was similar to the average labour costs in imports. The results are

surprising and differ from the prediction of Ricardian trade theory. According to Ricardian trade theory, a country will export those products whose cost is relatively low and import those products whose cost is relatively high.

Panel C of Table 5 shows the results for total factor productivity. Total factor productivity (TFP) is constructed as a weighted sum of capital and labour productivity using the share of capital and labour in total nominal income as weights.[4] We find that the level of TFP in export industries was 12 percent lower than in import industries in 1997. The relative TFP level of export and import industries did not change over the period 1981-1997. However, during the same period, export and import industries had faster labour productivity growth and faster TFP growth than the total business sector. Over that period, annual labour productivity growth was 2.7 percent in exports, 2.5 percent in imports and 1.3 percent in the total business sector. Annual TFP growth was 2.4 percent in exports, 2.3 percent in imports and 0.8 percent in the total business sector.

In Table 6, we consider average wages and productivity of exports and imports in the manufacturing sector. We find that export industries in manufacturing paid wages that were about 5 percent higher than import industries. Export industries in manufacturing had labour productivity that was similar to that in import industries, but had lower TFP. Over the period 1981-1997, labour productivity and TFP grew faster in the export and import component of manufacturing than in the overall manufacturing sector.

Table 5: Labour Costs and Productivity of Canadian Exports and Imports

	1981	1989	1997	Ratio of 1997 to 1981
	A. Real wage (of 1992 dollars per hour)			
Exports	17.49	18.18	18.36	1.05
Imports	17.47	17.60	18.14	1.04
Ratio	1.00	1.03	1.01	
Business Sector	16.35	16.64	17.18	1.05
	B. Labour productivity (GDP per hour, 1,000s of 1992 dollars)			
Exports	34.66	40.37	53.14	1.53
Imports	36.84	41.20	54.55	1.48
Ratio	0.94	0.98	0.97	
Business Sector	22.02	24.28	27.28	1.24
	C. Total factor productivity			
Exports	9.87	11.08	14.55	1.47
Imports	11.48	12.65	16.51	1.44
Ratio	0.86	0.88	0.88	
Business Sector	7.37	7.85	8.49	1.15

[4] We have chosen the capital share of income to be 0.3 and the labour share to be 0.7 for calculating TFP.

Table 6: Labour Costs and Productivity of Manufacturing Exports and Imports

	1981	1989	1997	Ratio of 1981 to 1997
	A. Real wage (1992 dollars per hour)			
Exports	19.32	19.61	19.72	1.02
Imports	18.45	18.56	19.02	1.03
Ratio	1.05	1.06	1.04	
Manufacturing Sector	18.99	19.27	19.92	1.05
	B. Labour productivity (GDP per hour, 1,000s of 1992 dollars)			
Exports	38.59	43.70	61.49	1.59
Imports	38.73	44.18	61.46	1.59
Ratio	1.00	0.99	1.00	
Manufacturing Sector	23.53	27.33	34.22	1.45
	C. Total factor productivity			
Exports	11.39	12.37	17.31	1.52
Imports	12.60	13.73	18.73	1.49
Ratio	0.90	0.90	0.92	
Manufacturing Sector	8.36	9.25	10.95	1.31

The Effect of Trade on Productivity Growth

Our finding that export and import industries had faster productivity growth than the total business sector is consistent with the view that trade is linked to higher productivity growth. But the faster productivity growth in exports and imports relative to the business sector might reflect a more rapid pace of technical progress that is taking place in export and import industries, and thus it should not be attributed solely to the effect of trade.

To estimate the effect of trade on productivity growth, we should control for the productivity growth that would have taken place in trade industries without trade. To that end, we compare the change in productivity growth in trade industries between the periods 1981-1989 and 1989-1997 with the change that occurred in the total business sector. If the productivity growth of export and import industries relative to the total business sector widened in the 1989-1997 period, we interpret this as evidence that trade is linked to higher productivity growth. The underlying assumption behind this difference-in-differences approach is that the productivity growth difference between traded industries and the business sector should remain unchanged if trade has no effect on productivity growth.[5]

Panel A of Table 7 shows that labour productivity growth increased for exports, imports and the total business sector in the period 1989-1997 vis-à-vis the period 1981-1989. But the increase was much faster in export and import

[5] It could be argued that the deep recession in the early 1990s could affect the extent to which a comparison of the two periods reflects only the effects of trade. However, if we assume the recession has a similar effect on productivity growth in the trade sector and the business sector, the difference-in-differences approach would control for such an effect (Trefler, 2004).

industries than in the business sector. This is consistent with the view that trade is linked to high labour productivity growth.

Between the periods 1981-1989 and 1989-1997, labour productivity growth in export industries increased from 1.9 percent per year to 3.4 percent per year, representing an acceleration of 1.5 percent per year between the two periods. For import industries, there was an acceleration of 2.1 percent per year: 1.4 percent per year in the period 1981-1989 versus 3.5 percent per year in the period 1989-1997. For the business sector, the labour productivity acceleration was much smaller (estimated to be 0.2 percent per year).

Panel B of Table 7 shows the results for TFP growth. The results suggest that trade is linked to high TFP growth. TFP growth in export and import industries was faster than in the business sector during the period 1981-1989. It became even faster in the 1989-1997 period, suggesting that trade is linked to high TFP growth.

Table 8 shows the results on the effect of trade on productivity growth in the manufacturing sector. Consistent with the view that trade has a positive effect on productivity growth in the manufacturing sector, the results show that export and import industries in the manufacturing have increased productivity growth relative to the total manufacturing sector over time.

Table 7: The Effect of Trade on Productivity Growth in the Business Sector

	1981-1989	1989-1997	Changes in two periods	Changes in two period relative to the business sector
A. Labour productivity growth (% per year)				
Exports	1.91	3.44	1.53	1.29
Imports	1.40	3.51	2.11	1.87
Total business sector	1.22	1.46	0.24	
B. Total factor productivity growth (% per year)				
Exports	1.44	3.40	1.96	1.76
Imports	1.21	3.32	2.11	1.92
Total business sector	0.79	0.98	0.20	

Table 8: The Effect of Trade on Productivity Growth in the Manufacturing Sector

	1981-1989	1989-1997	Changes in two periods	Changes in two period relative to the business sector
A. Labour productivity growth (% per year)				
Exports	1.55	4.27	2.71	1.77
Imports	1.65	4.13	2.48	1.54
Total manufacturing	1.87	2.81	0.94	
B. Total factor productivity growth (% per year)				
Exports	1.03	4.21	3.18	2.34
Imports	1.07	3.88	2.81	1.97
Total manufacturing	1.27	2.11	0.84	

The Effect of Trade on the Demand for Skilled Workers

Table 9 shows the skilled and unskilled labour requirements of Canadian exports and imports in 1997. The main result is that trade had little effect on the demand for skilled and unskilled workers in Canada. In 1997, output of Canadian exports required 816 million hours of work from workers with bachelor degree or above compared with 842 million hours of work implicit in imports. This resulted in a net trade loss of 26 million hours of work from those workers. The effect of net trade on employment of those workers was small as the net trade loss accounted for 0.9 percent of total hours worked from those workers.

Table 9: The Effect of Trade on Demand for Skilled and Unskilled Workers, 1997

	Exports	Imports	Net trade (1000 hours)	Total	Net trade (%)
Less than high school	326874	-303428	23446	1043617	2.2
High school	2026281	-1970165	56116	7540693	0.7
Post-secondary education	2202108	-2218120	-16012	8674273	-0.2
University or above	815952	-842371	-26419	3089005	-0.9
Total	5371216	-5334084	37132	20347588	0.2

The results in Table 9 show that trade increased the demand for unskilled workers (with less than post-secondary education) and reduced the demand for skilled workers. But the effect of trade on the demand for skilled and unskilled workers was small. We have also calculated the skilled and unskilled labour requirements of net trade for the years 1981, 1989 and 1991. The results are similar. Trade was found to have had little effect on the demand for skilled and unskilled workers in Canada.

Conclusion

In this paper, we have used an input-output model to examine the effect of trade on productivity growth and the demand for skilled workers in Canada. We have also examined the sources of comparative advantage in Canada's international trade. Our main findings are as follows:

First, we find that trade is linked to high labour and total factor productivity growth. For the period 1981-1997, productivity growth was faster in export and import industries than in the total business sector; this productivity growth gap has widened over time.

Second, we find that trade has little effect on the demand for skilled and unskilled workers. The skilled and unskilled labour requirements of net trade are small share of their total employment.

Third, Canada has comparative advantage in capital- and resources-intensive industries. While, comparative advantage in equipment and building structure capital-intensive industries declined over the 1990s, the comparative advantage in engineering structure capital increased over the period. Canada's comparative advantage in agriculture, forestry and fishery products and crude petroleum and natural gas has also fallen over time. Metal mines and other mines continue to be a main source of comparative advantage for Canada and have shown little change over time.

Fourth, despite a high share of more educated workers in Canada compared with the U.S. and other developed countries, we find that skills and human capital are not a source of comparative advantage in Canada's international trade. For the period 1981-1997, the skill composition is similar between exports and imports. In contrast, U.S. studies such as that by Wolff (2003) show that skills and human capital are sources of comparative advantage for the U.S., while physical capital (equipment and structure) is a source of comparative disadvantage in U.S. international trade.[6] It is interesting to note that while Wolff's study shows that the U.S. has a comparative advantage in human capital, it also shows that their R&D advantage has declined over time, such that the U.S. now has a comparative disadvantage in R&D. An examination of the R&D intensity of Canada's international trade is an interesting avenue for future research.

[6] Wolff (2003) did not calculate the natural resource content of U.S. trade.

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