Université de Montréal

The Dynamic Evolution of Factor Accumulations and Revealed Comparative Advantage in Canada

Zheng Zhang

Département de sciences économiques
Université de Montréal

Professor Leonard Dudley, my director of the research paper, and professor Emanuela Cardia provided countless creative ideas, documentary contributions, and positive suggestions, all of them essential to the task. I have been privileged to have their expert knowledge on international economics. My gratitude to them is boundless.

Amy, my fiancée, has been critically important to the project. Her success in arranging our lives to accommodate this whole paper made all the difference between progress and chaos.

Abstract

This paper seeks to theoretically and empirically examine the Factor Proportions Theory in a Canadian context.

The dual, general equilibrium trade model predicts that a faster growth of Canadian human capital stock than its physical capital stock tends to promote the production and export performance of the sectors that use intensively human capital and risks to deteriorate the development of its primary sectors that use intensively the physical capital.

The empirical results support the Heckscher-Ohlin prediction and the Rybczynski effect. Canada tended to export goods that are intensive in the factors with which it is relatively abundant. An increase in the supply of a factor of production systematically shifts Canada's production and export structures towards industries that intensively use that factor. In the long run, the data suggests that accumulation of physical capital in Canada improves the export performance of its primary sectors. However, the role of human capital is less clear. This poses a serious problem to the Canadian new economic policies that tend to encourage the development of knowledge-based economy. These policies should be targeted specifically on the activities in which the market failure occurs.

Brief Contents

Contents

List of Figures

List of Tables

1. Introduction

The concept of comparative advantage helps us to understand how differences between countries give rise to trade between them, and why this trade is mutually beneficial. In the simplest **Ricardian model**, countries will export goods that their labor produces relatively efficiently, and import goods that their labor produces relatively inefficiently. *A country's production pattern is determined by comparative advantage.* A country does not need to be good at everything to gain from trade and moreover it gains from trade even if it has lower productivity than its trading partner in all industries. The distribution of the gains from trade depends on the relative prices of the goods countries produce. This confirms the insight that trade depends on comparative advantage, but not absolute advantage.

However, if labor was the only factor of production, as the Ricardian model assumes, comparative advantage could arise only because of international differences in labor productivity. *In the real world, while trade is partly explained by differences in labor productivity, it also reflects differences in countries' resources.* For instance, Canada exports forest products to the United States, not because its lumbermen are more productive relative to their U.S. counterparts than other Canadians but because sparsely populated Canada has more forested land per capita than the United States. The **factor-proportions theory** developed by Heckscher and Ohlin shows that comparative advantage is influenced by the interaction between the resources of nations (the relative abundance of factors of production) and the technology of production (which influences the relative intensity with which different factors of production are used in the production of different goods). *The basic prediction of the Heckscher-Ohlin model is that countries tend to export goods that are intensive in the factors with which they are relatively abundant.*

This paper seeks to theoretically and empirically explain how the structure of Canadian exports changes with its accumulation of factors of production. Based on the dual and general equilibrium approach developed by Dixit and Norman (1980), Krugman and Helpman (1985) showed that even if factors of productions are divided up among countries and there is little international factor mobility, there exists a set of allocations of factors to countries for which it is possible to achieve the same resource allocation as if the goods and factors were perfectly mobile. If factor prices equalize, this set of factors assures that every country can fully employ its resources, using the techniques of production that are used in the integrated equilibrium. A country will be net exporter of the services of factors of which it has a relatively large share of the world supply. Numeric simulations predict that if Canada tends to increase its human capital stock more rapidly than its physical capital stock, it would lose its comparative advantage in its primary sectors that employ intensively physical capital.

Balassa (1979, 1988) developed a procedure that transposes the results obtained in "commodity space" into "country space", so as to test the "stages" approach to comparative advantage, according to which a country's comparative advantage changes with the accumulation of its factors of production. In his later work, Balassa (1986, 1987) combined the two stages of estimation into "one-pass" procedure and confirmed that inter-country differences in the structure of exports were in a large part explained by differences in factor endowments. However, his approach was basically static and the problem of dropping variables could be serious. The present paper extends Balassa's procedure by incorporating a dynamic aspect into the Factor Proportions Model.

This paper takes into consideration the fact that the differences in factor accumulation, productivity, and therefore comparative advantage are driven by differences in social infrastructure (Hall and Jones, 1999). Countries with long-standing policies and institutions favorable to productive activities – rather than departure – produce much more output per worker. For example, during the 1980s, the higher cost of obtaining funds in Canada than in Japan and in the United States, frequent changes in tax laws, highly variable interest rates, extreme fluctuations of exchange rates, and increased government regulations all contributed to the relatively low level of investment in Canada. Moreover, primary sectors play important roles in the Canadian industrial structure. For instance, the Canadian forest products manufacturing industry accounts for 11% of Canada's manufacturing GDP. As an export-focused industry, it contributes $35 billion to the country's trade balance, more than any other manufacturing sector.* In order to better specify the model, some Canada-specific dummy

* Productivity and Innovation: A Competitive and Prosperous Canada, Parliament of Canada, 2000.

variables have been introduced into the estimations. It has turned out that these variables are highly statistically significant.

Both the general equilibrium trade model and the data support the Heckscher-Ohlin theory and the Rybczynski effect. During the period covered by the data, Canada tended to export goods that are intensive in the factors with which it is relatively abundant. Increases in the supply of a factor of production systematically shift Canadian production and export structures towards industries that intensively use that factor. Factor proportions tend to be an important determinant of the structure of international trade.

The simulations suggest that Canadian government's promotion of its human capital stock risks to deteriorate the export performance of its traditional primary sectors in the long run.

This paper is organized as follows. Section 2 reviews the Canadian economic reality from 1970 to 1992. Section 3 presents the general equilibrium trade model and simulations. Section 4 examines the empirical results. Section 5 concludes.

2. The Canadian Economy From 1970 To 1992

Generally speaking, the 1960s was a period of rising inflation and falling unemployment in the OECD countries. It was also a period of rapid growth of GNP. Canada's business cycle had been well synchronized with that of the United States before 1980s, with peaks and troughs never more than three months apart in the two economies. As shown in Figure 2-1, from 1971 to 1973 the Canadian economy boomed, with the encouragement of American expansionary monetary and fiscal policies. The period 1973-1975 opened with restrictive monetary and fiscal to fight the high inflation caused by the first oil shock, and the Canadian economy plumped into a severe recession. After a strong recovery in 1976, a second oil shock caused the inflation to fly again in 1979. The recession experienced by Canada was more severe than the one of 1973. Thanks to the easy monetary policy in the United States, real Canadian GNP growth was exceptionally rapid during 1983 and 1984. Growth slowed substantially in 1985 and 1986, but the growth then resumed, reaching nearly 5% in 1988.

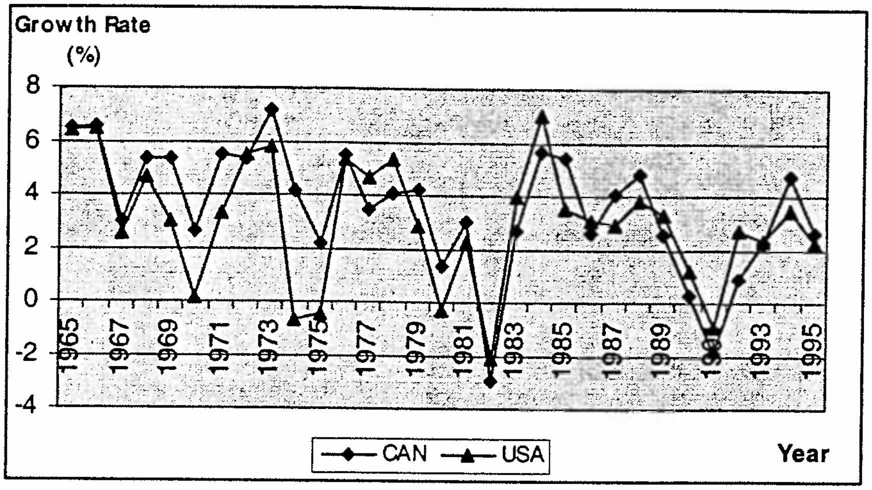
Other important characteristics in the Canadian economy are presented below:

A). Liberalization of trade and the Canadian economy

Canada can be depicted as a natural-resource abundant and energy-rich country, with a small labor force. In terms of technology, it is an importer as opposed to being a creator of technology and this importation is done mainly through licensing and foreign direct investment. The competitive strengths of Canada are located in resource-based technology, although the country has somewhat succeeded in exploiting some technological synergies from natural resources sectors within other industrial sectors, such as space and telecommunications.

The small and slow growing domestic market prevents Canada from achieving important economies of scale. Moreover, the largest local firms are still small according to international standards, and multinationals are mostly in the natural resources sector. There is a strong presence of foreign ownership, especially American multinationals. Although the country has been open to investment flows, during the 1970s there were general concerns and worries about

Figure 2-1. Growth rate of real GDP (1965-1995)



Source: Statistical Compendium OECD 1999 the loss of cultural sovereignty, especially with the United States. However, the screening of inward FDI has been considerably decreased in the last two decades.

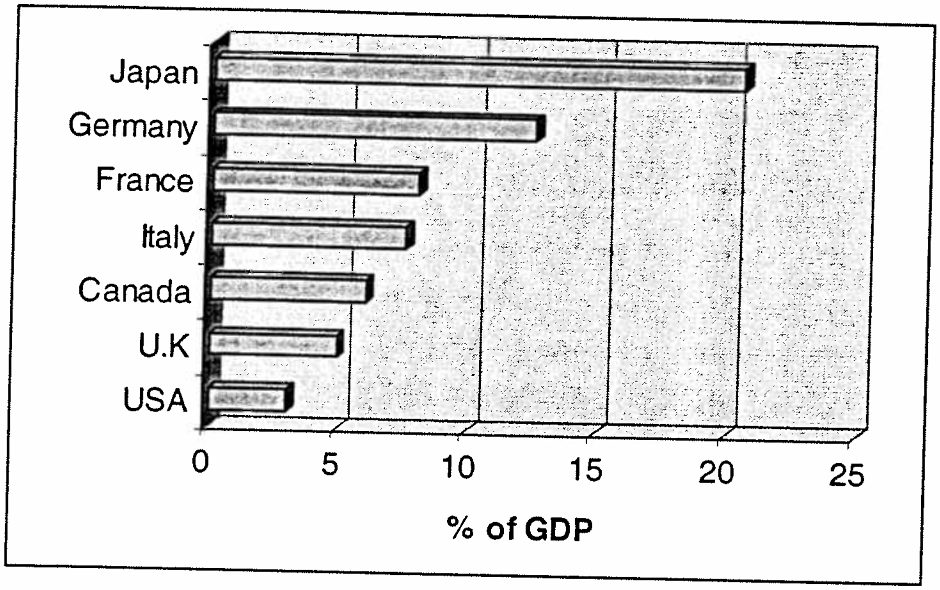
In terms of trade and investment strategy, high tariffs against imports have fallen since the Tokyo Round in 1979, and Canada is strongly committed to multilateral organizations such as GATT. The reduction of trade barriers with the United States has begun with the Auto Pact in 1965. In 1989, a first wave of agreements reducing trade barriers with the States took place under the Free Trade Agreement (FTA), and in 1994, these agreements have been extended to include Mexico as a third partner under the North American Free Trade Agreement (NAFTA).

B). Low investment rates in physical capital

There were serious concerns about Canadian savings and investment rates in the 1980s. Total Canadian gross savings (depreciation plus net savings) were relatively low in the 1980s. The Canadian savings rate is about one-third that of Japan, but twice the American rate (see Figure 2-2). As shown in Figure 2-3, much of the decline in savings is due to the huge government deficits in the 1980s. But both household and corporate savings rate have fallen too. During this period, many of the motives and incentives for savings changed in a way to discourage the Canadians to save. Improved public pensions and retirement savings programs (particularly during the 1970s) reduced the need for savings for retirement; improved capital markets and insurance – provided by both government and employers – meant that people didn't have to save as much for a down payment for a house; and improved government student-loan programs meant that parents didn't have to save as much for their children's education.

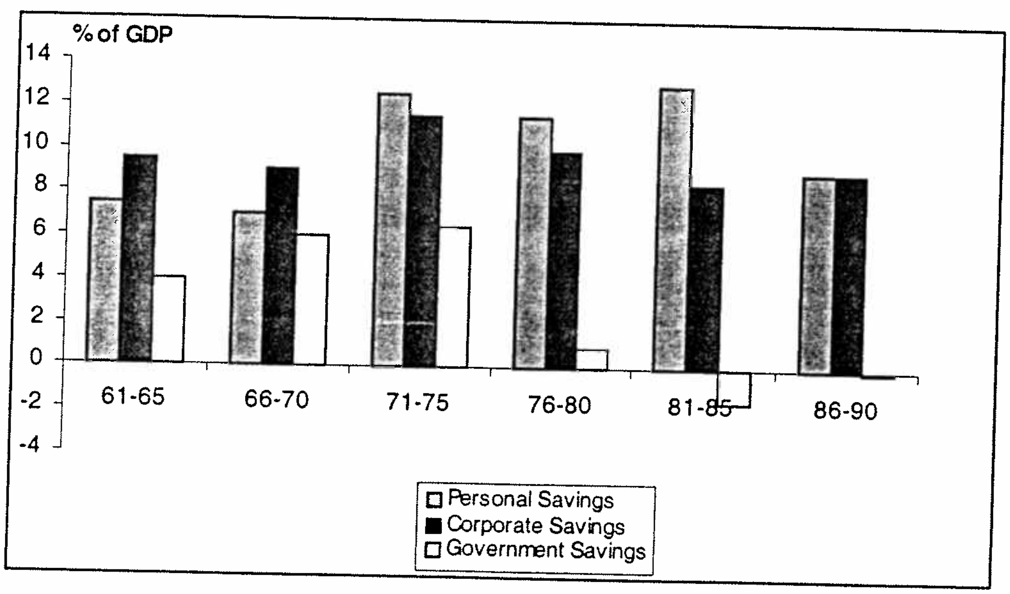
In the 1980s, the level of investment was low in Canada and much of its investment has gone into areas, such as real estate, that do not contribute much to long-run productivity growth. Several factors could be identified to explain the relatively low level of investment in Canada. First, during the 1980s and early 1990s, the Canadian government pursued some tight monetary policies combined with large government deficits. The cost of obtaining funds was higher in Canada than in the United States, and was substantially higher than in Japan. Real interest rates were very high and highly volatile, by historical standards. Funds became even less available in the late 1980s and early 1990s; as their real estate investments and other loans went sour, many

Figure 2-2. International Comparison of Savings Rates in 1990



Source: Economic Outlook, OECD 1990

Figure 2-3. The decline in Canadian savings



Source: Statistics Canada, CANSIM Database, 1993.

financial institutions responded to severe economic problems by tightening credit standards. Second, frequent changes in tax laws and extreme fluctuations of exchange rates caused a sense of business uncertainty. In the early 1980s, extremely favorable tax treatment to commercial real estate such as office buildings combined with a widespread belief that these treatments were too generous to be permanent spurred a boom in commercial real estate, which by the mid-1980s had resulted in oversupply. As anticipated, the tax reform of 1988 took most of the special treatment away. High exchange rate volatility during the 1980s discouraged Canadian producers from making any log-run commitments associated with investment. Third, there was a growing concern that the Canadian government's failure to maintain its infrastructure at an adequate level, and to improve it to keep pace with the potential growth of the economy would act as a dampening force on future economic growth. For instance, the Trans-Canada highway system that was created in the 1950s was not up to the burden of the 1990s.

It is generally understood that new capital, particularly that classified as Machinery & Equipment, is more likely to embody newer and best practice technologies than older capital. It has been estimated that most of all technical progress comes from, or is embodied in, new machinery & equipment. Thus, an aging capital stock (which may result from a lower capital investment rate) can reduce productivity growth simply because technical progress is coincidentally stunted. The mere slowing of the decline in the average age of M&E (that is, not simply an aging M&E) can slow both the rate of technical progress and productivity growth in the economy. This kind of development is often referred to as the *vintage effect*. Finally, since new physical capital also implies complementary worker training, a decline in capital investment may also entail a reduction in human capital investment -- another positive correlate of productivity. The Organisation for Economic Co-operation and Development (OECD) reports that net investment -- net of depreciation charges -- for its member countries hovered in the vicinity of 12% in the 1970s, 10% in the 1980s, and has trended down to about 5% in the 1990s.* Gu and Lee (1998) observed that in Canada, the patterns of changes in the age of machinery and equipment generally mirror that for the capital stock. During the 1963-73 period, the age of M&E declined in almost all industries.

* Technology, Productivity and Job Creation – Best Policy Practices, OECD, 1998

Only three service industries -- transport and storage; communications; and community, social and personal services -- showed a slight increase in the age of M&E. For the period 1973-92, capital accumulation in M&E decelerated in almost all industries except service industries, causing the reduction in the age of M&E to either reverse or slowdown. For most service industries, the age of M&E actually declined at a faster rate in 1973-92 than in 1963-73.

C). Canada's educational deficiencies

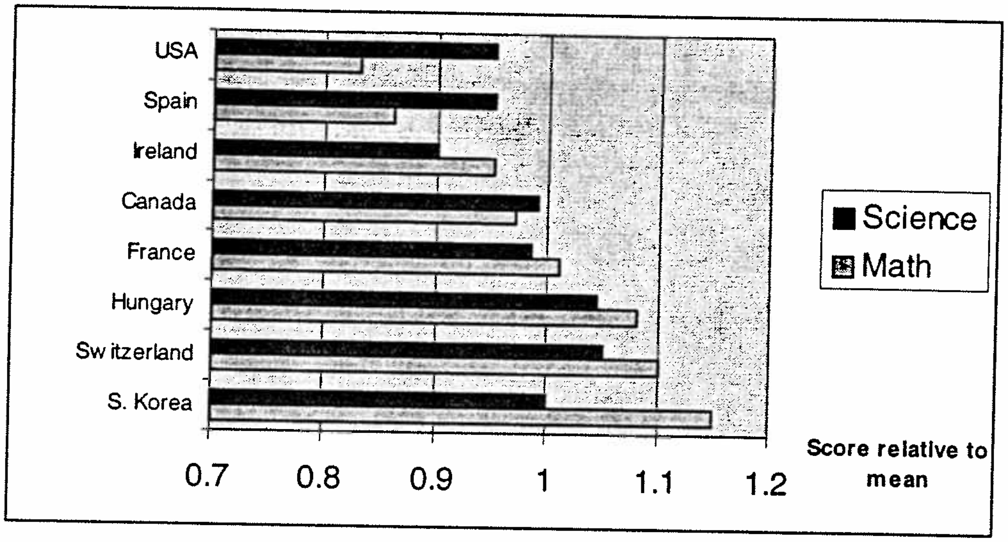
Despite the enormous resources that the Canadian government put into education and the fact that, along with the United States, the average number of years of schooling was among the highest in the world, there was concern that the Canadian were not getting value for money in their school and postsecondary institutions. For instance, in 1991, the average national score of Canadian students on standardized mathematics and science tests was below the average national score of students in South Korea, Switzerland and Hungary, but was above that of students in several other countries, including the United States (see Figure 2-4).

D). The Productivity Slowdown

For almost a century, Canada has benefited from its proximity to the United States and from the relatively open border that has allowed goods, capital, labor, and knowledge to flow freely back and forth. As the twentieth century drew towards its close, productivity levels and living standards in Canada remained among the highest in the world. However, the Canadian rates of growth of productivity slowed considerably in the late 1960s and early 1970s (see Figure 2-5). By the late 1970s, the rate of growth of productivity was less than half of what it was in the 1950s and 1960s. There appears to have been a small rebound in the 1980s, but nothing like a return to the earlier levels. The symptoms of the productivity slowdown were showing. As we know, over the long run, wage rates tend to change with productivity increases.

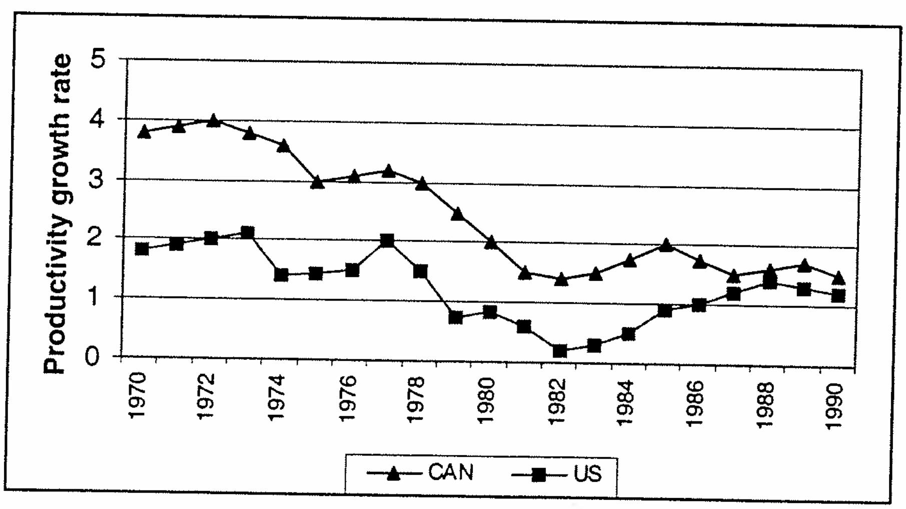
Lavoie and Finnie (1996) observed that the Canadian economic dependence on natural resources has had a tremendous impact on the development and direction of the Canadian technological capability over time, largely because a national technological capability

Figure 2-4. International comparison of performance on science and math tests in 1991



Source: *Education and Training in Canada*, Economic Council of Canada, Ottawa, 1992

Figure 2-5. Canadian and USA productivity trends

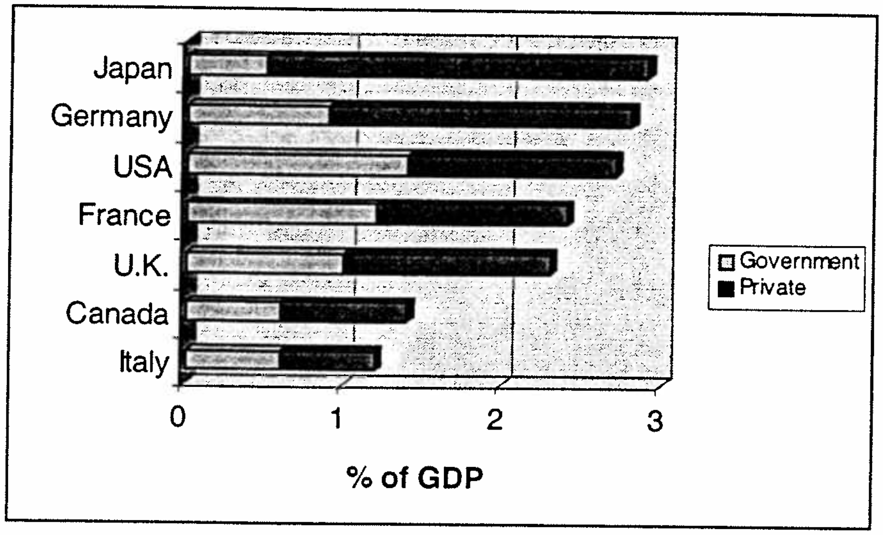


Source: Statistics Canada, CANSIM Database, 1993; Economic Report of the President 1992.

is built incrementally, and what a country has been able to do in the past is a principal determinant of what it can achieve in the future. According to the OECD, Canada is characterized by an innovation gap. The Canadian manufacturing sector is lagging behind in terms of innovation and, as competitiveness depends heavily on innovation, the future of Canada appears not as bright as was its past. Canada's productivity experts seem to agree that, rather than the entire manufacturing sector, two sub-sectors are primarily to blame: electrical and electronic equipment and industrial and commercial machinery. These sub-sectors form an integral part of the high technology sector, which appear to be important catalysts to the growth of national productivity in both countries. In contrast to medium and low technology industries, those in high technology are characterized more by product innovation than process innovation. Consequently, the Canada-United States productivity gap in manufacturing may be traced back to a product innovation gap between the two countries. The source of this gap is a deficiency of R&D, a Canadian failure to access American product and production process knowledge in a timely fashion, and slowness to adopt new technology, particularly in the high technology sector. Probably a more important source of poor productivity growth, however, has been a sluggish rate of capital investment by the Canadian manufacturing sector, particularly when compared to our major trading partner, the United States. A more debatable contributor to the innovation gap is the relative loss in foreign direct investment (FDI), an important factor on which Canada has traditionally relied for accessing and diffusing productivity-enhancing technologies and products. On the positive side, the Canada-United States Free Trade Agreement (FTA) has been identified as having enhanced the Canadian manufacturing sector's productivity growth.

The ratio R&D/GDP of the Canadian economy is the second lowest among the 7 largest OECD countries as depicted in Figure 2-6. Moreover, the business share of Canada's expenditures in R&D is also at the lowest rank. Thus, Canada invests less in R&D than its major competitors, and less of the total investment is by private sector. Although a certain level of public investment in R&D can be a good thing, it is generally recognized that the investments of business are critical for two main reasons. First, business not investing in R&D is a broad sign that technology is not a vibrant activity in the economy. Second, business investments are

Figure 2-6. International comparison of R & D expenditures in 1990



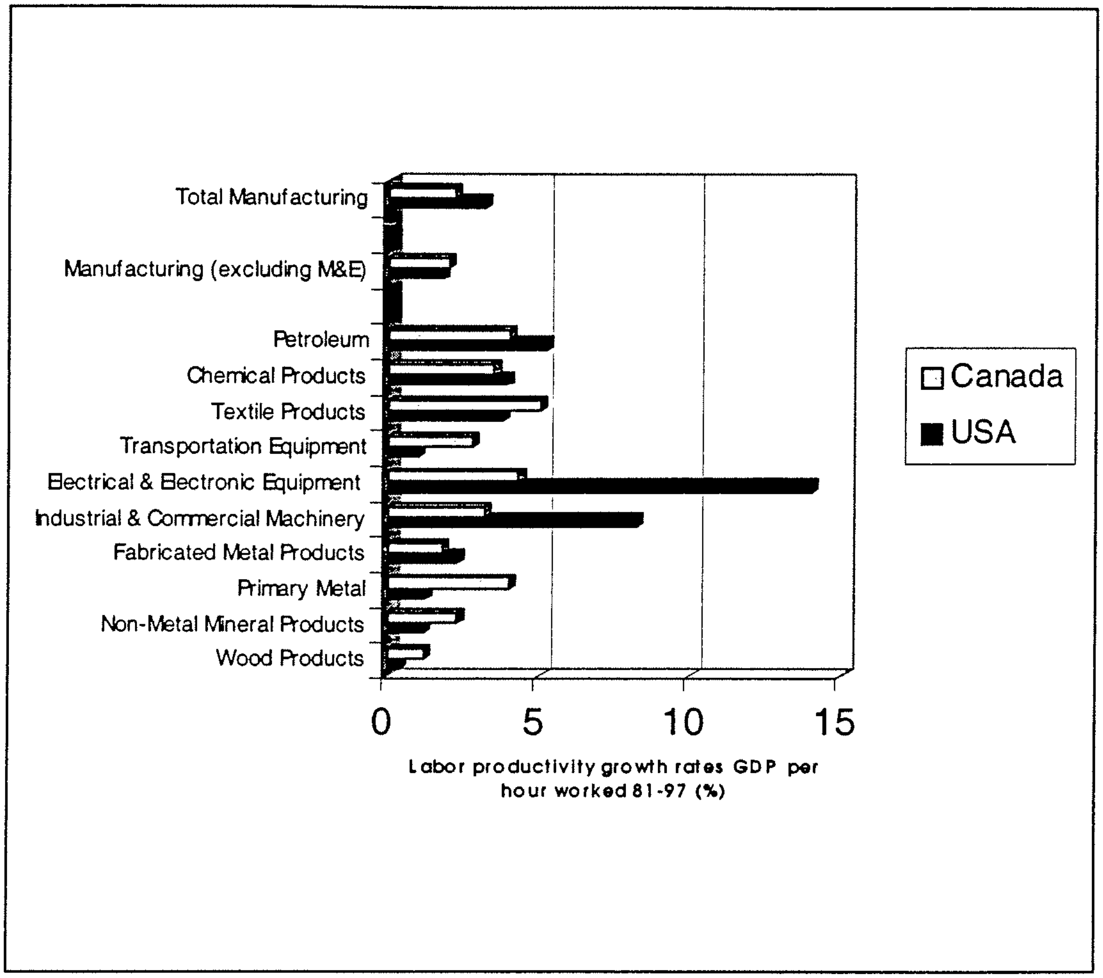
Source: *National Patterns of R & D*, National Science Foundation, 1990 usually thought to be a more critical element of the general dynamic of technological development. The low level of business investments is both a symptom and a cause of the relative lack of technological development of the nation. On the other hand, foreign firms in Canada finance a substantial amount of R&D as compared to the portion of these firms in other countries.

Striking in Canada's productivity performance is the fact that, overall, the business sector fared about the same, if not slightly better, than that of the United States for more than three decades. One significant sector, manufacturing, fared miserably, however. The value of manufacturing output represents approximately 20% of both economies and the similarity of these economies and their forces of change suggest, other things being equal, that their manufacturing performances should not have been so different. Figure 2-7 demonstrates both the similarities and dissimilarities between the labour productivity of various manufacturing industries in Canada and the United States over the 1981-97 period. Overall, the United States (3.2%) clearly outperformed Canada (2.2%) in this period; a difference of about one percentage point over roughly two decades can leave a significant mark on both economies.

What immediately stands out from Figure 2-7 is the disparity between the productivity of the electrical and electronic equipment and industrial and commercial machinery sub-sectors of the two countries, with the United States decidedly superior. Over a period of roughly two decades, this difference can have a significant impact on the structures of both economies.

Only one telling conclusion can be drawn from these results. If we accept that the high technology sector is fuelling much of the increase in economic activity and productivity, and is responsible for propelling the economy towards a knowledge-based society, then the United States is far more along this road than Canada. Viewed through these narrow lenses, the American manufacturing sector appears to be far better prepared for the future and for what prosperity and challenges it may hold than the Canadian manufacturing sector.

Figure 2-7. Comparison of labor productivity in Manufacturing between Canada and USA



Source: *New Estimates of Manufacturing Productivity Growth for Canada and the United States,* Centre for the Study of Living Standards 1998.

3. The General Equilibrium Trade Model

A). The integrated equilibrium

Based on the approach developed by Dixit and Norman (1980), Helpman and Krugman (1985) used the concept of **integrated equilibrium** as a reference point in a general equilibrium trade analysis. The integrated equilibrium is defined as the resource allocation the world would have if goods and factors were both perfectly mobile. They found that there exists a set of allocations of factors to countries for which it is possible to achieve the same resource allocation as at integrated equilibrium if factors of production are divided up among countries and there is no international factor mobility. If factor endowments lie within this set, factor prices will be equalized through trade. This set FPE (factor price equalization) includes all endowment distributions in which every country can fully employ its resources, using the techniques of production that are used in the integrated equilibrium. Vanek (1968) observed that if factor prices are equalized and if countries have identical homothetic preferences, then a relationship between factor endowments and trade could be deduced. A country will be net exporter of the services of factors of which it has a relatively large share of the world supply.

B). A numeric 2 x 2 x 2 example

We assume that the world is divided into two economies: Canada and Rest of the World (ROW). Each economy is able to produce two goods: human capital-intensive good X and physical capital-intensive good Y. Production of each good requires the use of two factors of production: human capital (H) and physical capital (K).

Moreover, we assume:

- Preferences are well behaved and homothetic which are represented by the utility function:

$$U = X^{1/2}Y^{1/2} \tag{3.1}$$

- The factors of production are inelastically supplied;

- Both goods are produced with quasi-concave, constant returns to scale production functions. We assume a unit cost function with each production function:

$$c_X(w) = w_K^{1/2} w_L^{1/2} \quad (3.2)$$

$$c_Y(w) = w_K + w_L \quad (3.3)$$

- There is perfect competition;
- All 2 goods are produced in both economies.

(i) Relation between factor prices and factor proportions

Differentiate (3.2) and (3.3) partially with respect to w_H and w_K. By Shephard's lemma for sector X, we have:

$$a_{KX} = \frac{1}{2} w_H^{1/2} w_K^{-1/2} \quad (3.4)$$

$$a_{HX} = \frac{1}{2} w_H^{-1/2} w_K^{1/2} \quad (3.5)$$

Then,

$$\frac{a_{KX}}{a_{HX}} = \frac{w_H}{w_K} \quad (3.6)$$

For sector Y, we have

$$a_{KY} = 1 = a_{HY} \quad (3.7)$$

Then,

$$\frac{a_{KY}}{a_{HY}} = 1 \quad (3.8)$$

(ii) Full employment of factors

Using these results, we can write the full employment conditions for each factor:

$$a_{HX} X + a_{HY} Y = \overline{H} \quad (3.9)$$

$$a_{KX} X + a_{KY} Y = \overline{K} \quad (3.10)$$

Substituting (3.10) into (3.6) and using the results from (3.7), we have:

$$a_{HX}X-(a_{KX}X+\overline{K})=\overline{H}$$

or

$$X=\frac{\overline{H}-\overline{K}}{a_{HX}-a_{KX}} \tag{3.11}$$

Substituting (3.11) into (3.10), we have:

$$Y=\frac{a_{HX}\overline{K}-a_{KX}\overline{H}}{a_{HX}-a_{KX}} \tag{3.12}$$

Divide (3.12) by a_{KX}, we have:

$$Y=\frac{(a_{HX}/a_{KX})\overline{K}-\overline{H}}{(a_{HY}/a_{KY})-1}. \tag{3.12'}$$

(iii) The consumer's problem

Form the Lagrangian:

$$L=X^{1/2}Y^{1/2}-\lambda(p_xX+p_yY-I_0).$$

Differentiating partially with respect to X and Y and setting $p_Y=1$, we obtain:

$$p_X=\frac{Y}{X}. \tag{3.13}$$

(iv) The price equations

The zero-profit conditions for the two sectors are:

$$a_{HX}w_H+a_{KX}w_K=p_X$$

$$a_{HY}w_H+a_{KY}w_K=1\ .$$

Solving these equations by Cramer's rule and then substituting from (3.5) , we obtain:

$$\frac{w_H}{w_K}=\frac{p_X-a_{KX}}{a_{HX}-p_X} \tag{3.14}$$

(v) Characteristics of the integrated equilibrium

From equations (3.6) and (3.14), we obtain:

$$p_X = \frac{2a_{KY}a_{HY}}{(a_{HY} + a_{KY})} \qquad (3.15)$$

Substituting from (3.11) and (3.12) into (3.13), we have:

$$p_X = \frac{a_{HX}\overline{K} - a_{KX}\overline{H}}{\overline{H} - \overline{K}} \qquad (3.16)$$

From (3.15) and (3.16), we have:

$$\overline{K}\left(\frac{a_{HX}}{a_{KX}}\right)^2 - 3(\overline{H} - \overline{K})\left(\frac{a_{HX}}{a_{KX}}\right) - \overline{H} = 0$$

This equation has the form of the quadratic equation $ax^2 + bx + c$, where:

$a = \overline{K}$, $\qquad b = -3(\overline{H} - \overline{K})$, $\qquad c = -\overline{H}$.

The solution is:

$$\frac{a_{HX}}{a_{KX}} = \frac{3(\overline{H} - \overline{K}) \pm \sqrt{9(\overline{H} - \overline{K})^2 + 4\overline{K}\overline{H}}}{2\overline{K}}. \qquad (3.17)$$

Let the positive root be r.

Substitute into (3.12'), we have:

$$\overline{Y} = \frac{r\overline{K} - \overline{H}}{r - 1} \qquad (3.18)$$

Human capital in sector X may be calculated from equation (3.9) and (3.7):

$$H_X \equiv a_{HX}X = \overline{H} - a_{HY}\overline{Y} = \overline{H} - \overline{Y} \qquad (3.19)$$

Physical capital in sector X may be calculated from equation (3.10) and (3.7):

$$K_X \equiv a_{KX} X = \overline{K} - a_{KY} \overline{Y} = \overline{K} - \overline{Y} \qquad (3.20)$$

Substituting into the production function for X, we obtain:

$$\overline{X} = 2 \ H_X^{1/2} K_X^{1/2} \qquad (3.21)$$

Differentiating (3.21) partially with respect to L and K, we obtain the marginal products in terms of X.

$$w_H / p_X = H_X^{-1/2} K_X^{1/2} \qquad (3.22a)$$

$$w_K / p_X = H_X^{1/2} K_X^{-1/2} \qquad (3.22b)$$

From (3.13), $P_X = Y / X$. After substitution into (3.22a) and (3.22b), we have:

$$w_H = H_X^{-1/2} K_X^{1/2} (X / Y) \qquad (3.23)$$

$$w_K = H_X^{1/2} K_X^{-1/2} (X / Y). \qquad (3.24)$$

World income $\overline{R}$ is:

$$\overline{R} = w_H \overline{H} + w_K \overline{K}. \qquad (3.25)$$

If factor-price equalization holds, we can insert factor supplies into equations (3.11) and (3.12') to obtain levels of $X_{CAN}, Y_{CAN}, R_{CAN}, X_{ROW}, Y_{ROW}$ and R_{ROW}.

Let N_{CAN}^H be Canada's net import of human capital, N_{CAN}^K be Canada's net import of physical capital and s_{CAN} be Canada's relative size measured by GDP:

$$s_{CAN} = \frac{R_{CAN}}{\overline{R}} = \frac{w_K K_{CAN} + w_H H_{CAN}}{w_K \overline{K} + w_H \overline{H}} \qquad (3.26)$$

Then

$$N_{CAN}^H = s_{CAN} \overline{H} - H_{CAN} \qquad (3.27)$$

$$N_{CAN}^K = s_{CAN} \overline{K} - K_{CAN} \qquad (3.28)$$

A positive N_{CAN}^H (N_{CAN}^K) means that Canada is a net importer of human (physical) capital and a negative N_{CAN}^H (N_{CAN}^K) means that Canada is a net exporter of human (physical) capital.

C). How to measure Canada's comparative advantage?

Thanks to the pioneering work done by Balassa (1965, 1977, 1979 and 1988), Canada's relative export performance in individual product categories can be taken to reflect its 'revealed' comparative advantage within the manufacturing sector, and can be expressed as the ratio of its share in the two countries' total exports of product i to its share in the two countries' exports of both goods:

$$RCA_{CAN} = \frac{\text{(CAN Export in good i) / (Total Exports in i)}}{\text{(Can Export in both goods) / (Total Exports in both goods)}} \qquad (3.29)$$

The RCA index is the Canadian share in the total exports of category i relative to the Canadian share in total exports of everything. When it is greater than 1, Canada enjoys revealed comparative advantage in good i; when it is less than 1, it is considered to suffer revealed comparative disadvantage.

D). Simulations

i) An increase in Canadian physical capital stock

Before the increase in K, we assume:

$$\overline{H} = 2, \overline{K} = 1, H_{CAN} = 0.80, K_{CAN} = 0.55, H_{ROW} = 1.20, K_{ROW} = 0.45.$$

As shown in Table 3-1, Canada is relatively physical capital abundant and relatively human capital rare. Before an increase by 0.1 of physical capital, Canada is net exporter of its abundant factor –physical capital K, since $N^{K}_{CAN} = -0.05$, and net importer of its rare factor – human capital H with $N^{H}_{CAN} = 0.19$. Canada enjoys a comparative advantage in the K-intensive product Y and suffers a comparative disadvantage in the H-intensive product X with $RCA^{Y}_{CAN} = 1.87, RCA^{X}_{CAN} = 0.51$. This proves the predictions of Heckscher-Ohlin-Vanek theory.

If we increase Canadian physical capital by 0.1 and ROW's remains the same, we can see that Rybczynski effect predominates: Canadian production of the physical intensive good Y increases, however, its production of human capital intensive good X decreases even the world production of X increases. The Heckscher-Ohlin-Vanek predictions still hold.

ii) An increase in Canadian human capital stock

We have the same initial situation here:

$$\overline{H} = 2, \overline{K} = 1, H_{CAN} = 0.80, K_{CAN} = 0.55, H_{ROW} = 1.20, K_{ROW} = 0.45.$$

As before, Canada is relatively physical capital abundant and relatively human capital rare. It is net exporter of its abundant factor – physical capital K and net importer of its rare factor – human capital H. Canada enjoys a comparative advantage in the K-intensive product Y and suffers a comparative disadvantage in the H-intensive product X.

If we only increase Canadian human capital by 0.1 and ROW's remains the same, we can see in the Table 3-2 that Rybczynski effect predominates once more: Canadian production of the physical intensive good Y decreases, however, its production of human capital intensive good X increases.

Table 3-1. Simulation of an increase by 0.1 in physical capital stock.

	World		Rest of the World		Canada	
Time	Before	After	Before	After	Before	After
K	1	1.1	0.45	0.45	0.55	0.65
H	2	2	1.2	1.2	0.8	0.8
K/H	0.5	0.55	0.375	0.375	0.6875	0.8125
Y	0.609612	0.6610957	0.157209	0.084246	0.452403	0.576849
X	1.473487	1.5331677	1.105115	1.27764	0.368372	0.255528
R	1.219224	1.3221914	0.614418	0.63516	0.604806	0.687032
s			0.503942	0.480384	0.496058	0.519616
N^{H}_{CAN}			-0.19212	-0.23923	0.192116	0.23923
N^{K}_{CAN}			0.053942	0.078422	-0.05394	-0.078422
Exports of X ($)	0.73384	0.7866337	0.548202	0.663882	0.185638	0.122752
Exports of Y ($)	0.305969	0.3208849	0.077985	0.043776	0.227985	0.277109
Total ($)	1.039809	1.1075186	0.626186	0.707658	0.413623	0.399861
RCA in X			1.240478	1.320827	0.512656	0.434981
RCA in Y			0.176465	0.087652	1.873169	2.245672

Table 3-2. Simulation of an increase by 0.1 in human capital stock.

	World		Rest of the World		Canada	
Time	Before	After	Before	After	Before	After
K	1	1	0.45	0.45	0.55	0.55
H	2	2.1	1.2	1.2	0.8	0.9
K/H	0.5	0.47619	0.375	0.375	0.6875	0.611111
Y	0.609612	0.613495	0.157209	0.186474	0.452403	0.427021
X	1.473487	1.51597	1.105115	1.033616	0.368372	0.482354
R	1.219224	1.22699	0.614418	0.604766	0.604806	0.622224
s			0.503942	0.492886	0.496058	0.507114
N^{H}_{CAN}			-0.19212	-0.16494	0.192116	0.16494
N^{K}_{CAN}			0.053942	0.042886	-0.05394	-0.04289
Exports of X ($)	0.73384	0.761907	0.548202	0.524161	0.185638	0.237745
Exports of Y ($)	0.305969	0.305036	0.077985	0.094564	0.227985	0.210473
Total ($)	1.039809	1.066943	0.626186	0.618725	0.413623	0.448218
RCA in X			1.240478	1.186333	0.512656	0.75158
RCA in Y			0.176465	0.21656	1.873169	1.595812

iii) 10% increase in both Canadian human and physical capital stocks

We have the same initial situation here:

$$\overline{H} = 2, \overline{K} = 1, H_{CAN} = 0.80, K_{CAN} = 0.55, H_{ROW} = 1.20, K_{ROW} = 0.45.$$

If we increase Canadian human and physical capital by 10% and ROW's remains the same, we can see from Table 3-3 that both productions of X and Y increase. With the same ratio K/H, Canada is still relatively abundant in physical capital. The Heckscher-Ohlin-Vanek predictions still hold: Canada is net exporter of its abundant factor – physical capital K and net importer of its rare factor – human capital H. Canada enjoys a comparative advantage in the K-intensive product Y and suffers a comparative disadvantage in the H-intensive product X. However, what appears interesting is that Canada actually improves its export performance of good X – the one that is produced with its relatively rare factor. The export performance of good Y is slightly deteriorated. As a result, the same percentage growth of factor accumulation seems to favour the production of the good that is produced with the rare factor.

v) Stronger growth rate in Canadian human capital stock than in its physical capital stock

We start with the same initial situation:

$$\overline{H} = 2, \overline{K} = 1, H_{CAN} = 0.80, K_{CAN} = 0.55, H_{ROW} = 1.20, K_{ROW} = 0.45.$$

If Canadian human capital increased by 20% and its physical capital increases only by 10%, we can see from Table 3-4 that both productions of X and Y increase. With its ratio K/H still higher than $\overline{K}/\overline{H}$, Canada is still relatively abundant in physical capital. The Heckscher-Ohlin-Vanek predictions still hold: Canada is net exporter of its abundant factor – physical capital K and net importer of its rare factor – human capital H. Canada enjoys a comparative advantage in the K-intensive product Y and suffers a comparative disadvantage in the H-intensive product X. However, Canada improves its export performance of good X – the one that is produced with its relatively rare factor. The export performance of good Y is slightly deteriorated. In fact, the net Canadian export of K remains the same and its net import of H decreases.

Table 3-3. Simulation of an increase by 10% in both physical and human capital stock

Time	World Before	World After	Rest of the World Before	Rest of the World After	Canada Before	Canada After
K	1	1.055	0.45	0.45	0.55	0.605
H	2	2.08	1.2	1.2	0.8	0.88
K/H	0.5	0.507212	0.375	0.375	0.6875	0.6875
Y	0.609612	0.64187	0.157209	0.14771	0.452403	0.49416
X	1.473487	1.541602	1.105115	1.128001	0.368372	0.413601
R	1.219224	1.28374	0.614418	0.617371	0.604806	0.666369
s			0.503942	0.480916	0.496058	0.519084
N^{H}_{CAN}			-0.19212	-0.1997	0.192116	0.199695
N^{K}_{CAN}			0.053942	0.057366	-0.05394	-0.05737
Exports of X ($)	0.73384	0.784435	0.548202	0.585528	0.185638	0.198907
Exports of Y ($)	0.305969	0.314323	0.077985	0.076674	0.227985	0.23765
Total ($)	1.039809	1.098758	0.626186	0.662202	0.413623	0.436557
RCA in X			1.240478	1.238519	0.512656	0.645598
RCA in Y			0.176465	0.164063	1.873169	1.850001

Table 3-4. Simulation of increases by 10% in physical capital stock and 20% in human capital Stock.

Time	World Before	World After	Rest of the World Before	Rest of the World After	Canada Before	Canada After
K	1	1.055	0.45	0.45	0.55	0.605
H	2	2.16	1.2	1.2	0.8	0.96
K/H	0.5	0.488426	0.375	0.375	0.6875	0.630208
Y	0.609612	0.645151	0.157209	0.171822	0.452403	0.473329
X	1.473487	1.575894	1.105115	1.069611	0.368372	0.506283
R	1.219224	1.290301	0.614418	0.609707	0.604806	0.680594
s			0.503942	0.47253	0.496058	0.52747
N^{H}_{CAN}			-0.19212	-0.17933	0.192116	0.179334
N^{K}_{CAN}			0.053942	0.04852	-0.05394	-0.04852
Exports of X ($)	0.73384	0.803421	0.548202	0.564187	0.185638	0.239234
Exports of Y ($)	0.305969	0.314293	0.077985	0.090631	0.227985	0.223662
Total ($)	1.039809	1.117714	0.626186	0.654818	0.413623	0.462896
RCA in X			1.240478	1.198644	0.512656	0.732304
RCA in Y			0.176465	0.196113	1.873169	1.642043

4. The Empirical Results

A). Revealed Symmetric Comparative Advantage -- RSCA

Since the RCA index ranges from zero to infinity, it turns out to produce a result that cannot be compared on both side of unity. In order to make the index be symmetric, Laursen (1998) introduced a measure called 'Revealed Symmetric Comparative Advantage' (RSCA):

$$RSCA = \frac{RCA - 1}{RCA + 1} \qquad (4.1)$$

The RSCA index ranges from –1 to 1 and ensures the normality of the distribution of the index. As we will see below, the utilization of the RSCA index can indeed improve the statistical significance of the estimators.

B). Two-stage procedure

The model extends the two-stage procedure and one-pass procedure developed by Balassa (1979, 1988) to test the hypothesis that Canada's structure of exports changes with its accumulation of physical and human capital from 1970 to 1992.

Let's begin with the two-stage procedure. The first stage of estimation is represented by equation (4.2), where revealed comparative advantage indexes (RCA) are related to variables k and h that represent the capital and human intensities of individual product categories. A positive β coefficient indicates that Canada has a comparative advantage in physical capital-intensive products; a positive γ coefficient indicates that Canada has a comparative advantage in human capital-intensive products.

$$RCA_i = \alpha_i + \beta_i k_i + \gamma_i h_i + \mu \qquad (4.2)$$

In the second stage, the hypothesis that the differences in the regression coefficients obtained can be explained by differences in endowment characteristics is tested. In so doing, the coefficients β and γ are regressed on variables representing Canada's physical and human capital endowments in an inter-country framework. The basic estimating equations are shown in (4.3) and (4.4):

$$\beta_i = b_1 + b_2 K_i + b_3 H_i + v_1 \qquad (4.3)$$

$$\gamma_i = c_1 + c_2 K_i + c_3 H_i + v_2 \qquad (4.4)$$

where K refers to Canada's per capita physical capital endowments and H to Canada's per capita human capital endowments. Positive b_2 and c_3 provide support to the Heckscher-Ohlin theory: a country that is relatively abundant in physical and in human capital tends to export relatively physical and human intensive products. On the other hand, negative b_3 and c_2 confirm the Rybczynski effect: increases in Canada's supply of physical (human) capital K (H) have a favorable (negative) impact on the export performance of its physical capital intensive products and a negative (positive) impact on its human capital intensive products.

Table 4-1 presents the results of estimation for equation (4.2) using the classic OLS method. The data set contains 13 categories of Canadian manufactured goods from 1970 to 1992. The dummy variable is to capture the heavy weight of natural resource sector in Canadian economy. As shown in the table, all estimators are not statistically significant at the 5% level, either using RCA or RSCA as dependent variable. So, the two-stage of estimation presented above will be replaced by the application of a one-pass procedure. The use of this one-pass method is supposed to produce similar coefficient values as the two-stage procedure, but it raises the statistical significance of the coefficients to some extent.

Table 4-1. OSL Regression Coefficients for EQ(4.8)

Year	RCA				RSCA			
	R-squared	DUMMY	K/L	H/L	R-squared	DUMMY	K/L	H/L
1970	0.6894	2.073281*	-5.59e-06	.1954716	0.6698*	.8033666	-3.69e-06	.408608
1971	0.4396	-.5562649*	-4.90e-07	.0264771	0.5114*	-.4079328	4.64e-07	.0007886
1972	0.7158	2.396968*	-8.09e-06	.3432533	0.6780*	.8206694	-3.47e-06	.4113416
1973	0.7105	2.391247*	-8.49e-06	.3652655	0.6849*	.7926571	-3.75e-06	.4548224
1974	0.6589	2.468238*	-6.45e-06	.0282482	0.6530*	.7745563	-3.23e-06	.347822
1975	0.6153	2.43752*	-3.21e-06	-.3404134	0.6266*	.7520426	-2.61e-06	.3131409
1976	0.6615	2.572951*	-7.47e-06	.4853346	0.6698*	.7894312	-3.33e-06	.6441877
1977	0.7051	2.769365*	-8.00e-06	.5050646	0.6779*	.8167722	-3.53e-06	.7090749
1978	0.7289	2.767858*	-5.40e-06	-.2002341	0.6470*	.7769512	-2.54e-06	.5469591
1979	0.7073	2.630564*	-4.92e-06	-.2012965	0.6069*	.7225209	-1.79e-06	.2600705
1980	0.7297	2.57817*	-1.90e-06	-.5844818	0.6692*	.7188971	-9.17e-07	.2301231
1981	0.6927	2.322841*	-1.05e-06	-.49121	0.6449*	.6685538	-1.40e-06	.3570878
1982	0.6610	2.17977*	-1.25e-06	-.3821972	0.5976*	.6695784	-1.59e-06	.3318578
1983	0.6681	2.163258*	-4.40e-06	.3149834	0.6279*	.6643708	-2.26e-06	.6308726
1984	0.6391	1.944149*	-5.40e-06	.5655686	0.6324*	.6195249	-2.61e-06	.664982
1985	0.6507	1.989077*	-7.02e-06	.7954252	0.6421*	.5951023	-3.14e-06	.7357544
1986	0.6741	2.066907*	-7.11e-06	.7969224	0.6421*	.6308068	-3.04e-06	.6728287
1987	0.7134	2.259125*	-5.73e-06	.4808452	0.6461*	.6449957	-2.30e-06	.5461056
1988	0.6885	2.128085*	-4.99e-06	.5686244	0.6300*	.6008647	-2.33e-06	.6718345
1989	0.7346	2.304048*	-3.13e-06	.1613297	0.6495*	.6736649	-1.62e-06	.5504868
1990	0.7309	2.275237*	-3.69e-06	.2610963	0.6215*	.6427756	-1.75e-06	.6018264
1991	0.7516	2.305137*	-2.72e-06	.1107644	0.6389*	.6672733	-1.11e-06	.4755015
1992	0.7805	2.38068*	-4.31e-06	.5763869	0.6990*	.6667848	-2.20e-06	-1.222156

Note: **1. Category Characteristic: Dummy = 1 for WOD, PAP & BMI, 0 for others.**

2. * Indicates statistical significance at the 5% level.

C). One-pass procedure

Equations (4.5) to (4.7) provide the derivation of the one-pass equation (4.8). This method gives similar coefficient values as the two-stage procedure, but it generally raises the statistical significance of the coefficients to some extent. This is explained by the fact that combining the two stages increases the number of observations in the estimating equation.

$$RCA_i = \alpha_i + \beta_i k_i + \gamma_i h_i + \mu \quad (4.5)$$

$$\beta_i = b_1 + b_2 K_i + b_3 H_i + v_1 \quad (4.6)$$

$$\gamma_i = c_1 + c_2 K_i + c_3 H_i + v_2 \quad (4.7)$$

$$RCA_i\ (RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + \varepsilon_i \quad (4.8)$$

where $\varepsilon_i = v_1 k_i + v_2 h_i + \mu$.

The coefficients of k_i and h_i in equation (4.8) can be interpreted as the constants of the second-stage equations, and the coefficients of $K_i k_i$, $H_i k_i$, $K_i h_i$, and $H_i h_i$ as the coefficients of K_i and H_i in the equations (4.6) and (4.7).

Table 4-2 shows us the results of panel estimation of equation (4.8) using 4,186 observations from the 14 OECD countries. Human capital intensity (h) is defined as total labor-hour used in the production adjusted by human capital per labor. Physical capital intensity (k) is defined as total physical capital adjusted by physical capital per labor. Physical capital endowment (K) is defined as physical capital per labor adjusted by average physical capital used. Human capital endowment (H) is defined as human capital per labor adjusted by average human capital used.

All the estimators are statistically significant at the 5% level. The positive signs of the coefficients for Kk and Hh confirm the Heckscher-Ohlin theory: countries tend to export goods whose production is relatively intensive in factors of which they have a relatively abundant supply.

The negative signs of the coefficients for Kh and Hk prove the Rybczynski effect: increases in a country's supply of physical (human) capital K (H) have a favorable (negative) impact on the export performance of its physical capital intensive products and a negative (positive) impact on its human capital intensive products.

Table 4-2. TOTAL (plain OLS) Estimates of equation (4.8):

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + \varepsilon_i$$

Variable	RCA Coefficient	RSCA Coefficient
k	1.07867*	.495704*
	(3.69245)	(5.80930)
Kk	1.03780*	.436905*
	(6.17138)	(8.89470)
h	-1.42533*	-.781719*
	(-3.4695)	(-6.51446)
Hh	1.86529*	1.19070*
	(5.01792)	(10.9662)
Kh	-1.94299*	-.870069*
	(-7.4805)	(-11.4681)
Hk	-.697900*	-.468422*
	(-3.2076)	(-7.37052)
α	1.11869*	-.088597*
	(12.1229)	(-3.28694)

Note: 1. Observations: 4,186.

2. Standard errors in ().

3. * indicates statistical significance at the 5% level.

In order to capture other Canada-specific characteristics, such as the social infrastructure and industrial structure, a dummy variable is introduced in equation (4.9):

$$RCA_i\ (RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 DCAN + \varepsilon_i \quad (4.9)$$

As shown in Table 4-3, the coefficient of DCAN using RCA as dependent variable is not statistically significant even at 15% level; on the other hand, the estimation with RSCA as dependent variable is significant at 5% level. *The negative sign of DCAN indicates that during the period from 1970 to 1992, the export performance of Canada under-performed that of the OECD countries because of factors other than resources defined as physical and human capital.*

Table 4-3. TOTAL (plain OLS) Estimates of equation (4.9)

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 DCAN + \varepsilon_i$$

Variable	RCA Coefficient	RSCA Coefficient
k	1.05823*	.514146*
	(3.61793)	(6.02907)
Kk	1.03745*	.437227*
	(6.16985)	(8.91866)
h	-1.34042*	-.858302*
	(-3.22539)	(-7.08377)
Hh	1.78483*	1.26327*
	(4.74112)	(11.5097)
Kh	-1.91944*	-.891305*
	(-7.37392)	(-11.7445)
Hk	-.709862*	-.457633*
	(-3.26016)	(-7.20885)
DCAN	.085932***	-.077504*
	(1.34725)	(-4.16775)
α	1.11353*	-.083946*
	(12.0579)	(-3.11782)

Note: 1. Observations: 4,186.

2. Standard errors in ( ).

3. * indicates statistical significance at the 5% level, *** at the 20% level.

In order to capture the importance of the primary sectors in the Canadian economy, two dummies are introduced in equation (4.10): Primary and Cprimary.

$$RCA_i(RSCA_I) = \alpha_i + b_1k_i + b_2K_ik_i + b_3H_ik_i + c_1h_i + c_2K_ih_i + c_3H_ih_i + d_1PRIMARY + d_2CPRIMARY + \varepsilon_i \tag{4-10}$$

Table 4-4 confirms that Cprimary is statistically significant at the 5% level and the Canadian export performance is highly influenced by its primary sectors.

Table 4-4. TOTAL (plain OLS) Estimates of equation (4.10)

$$RCA_i\ (RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 PRIMARY + d_2 CPRIMARY + \varepsilon_i$$

Variable	RCA Coefficient	RSCA Coefficient
k	1.26137*	.556162*
	(4.48421)	(6.64605)
Kk	.912148*	.396903*
	(5.63029)	(8.23512)
h	-1.42015*	-.791137*
	(-3.59722)	(-6.73601)
Hh	1.82698*	1.16561*
	(5.11244)	(10.9639)
Kh	-2.11094*	-.906112*
	(-8.45271)	(-12.1961)
Hk	-.668741*	-.447240*
	(-3.19501)	(-7.18249)
PRIMARY	.404204*	.032499*
	(10.4048)	(2.81208)
CPRIMARY	1.61141*	.463368*
	(12.8452)	(12.4160)
α	1.10895*	-.078229*
	(12.4547)	(-2.95330)

Note:
1. PRIMARY =1 for WOD, PAP and BMI, =0 otherwise.
2. CPRIMARY = DCAN x PRIMARY
3. Observations: 4,186.
4. Standard errors in ( ).
5. * indicates statistical significance at the 5% level.

In the long run, the accumulation of a factor of production can have biased effect on the performance of a country's exportation. Equation (4.11) tends to capture some of this effect:

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2\, K_i k_i + b_3\, H_i k_i + c_1 h_i + c_2\, K_i h_i + c_3\, H_i h_i + d_1 TK_i k_i + d_2 TH_i h_i + \varepsilon_i \qquad (4.11)$$

TKk and THh are dynamic counterparts of Kk and Hh. Table 4-5 shows the results of the panel estimation using the same 4,186 observations in this dynamic context for all 14 OECD countries.

The estimators of k, h, Kk, and Hh show that Heckscher-Ohlin predictions and Rybczynski effect still remain statistically significant, either using RCA or RSCA as independent variable.

With RCA as dependent variable, the estimators for TKk, THh are not statistically significant. However, with RSCA as dependent variable, we've found that TKk is still not statistically significant at any level, but the significance of THh is much improved and is now statistically significant at 16% level. So, in the long run, accumulation of human capital may have a positive biased impact on a country's export performance. However, the long-run effect from accumulation of physical capital is not so clear.

Table 4-5: TOTAL (plain OLS) Estimate of equation (4.11):

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 TK_i k_i + d_2 TH_i h_i + \varepsilon_I$$

Variable	RCA Coefficient	RSCA Coefficient
k	1.04731*	.507983*
	(3.53892)	(5.88259)
Kk	1.00883*	.440575*
	(5.81044)	(8.69629)
h	-1.38795*	-.816099*
	(-3.33841)	(-6.72716)
Hh	1.85599*	1.22309*
	(4.96643)	(11.2163)
Kh	-1.90648*	-.889275*
	(-7.17501)	(-11.4696)
Hk	-.694523*	-.482320*
	(-3.18284)	(-7.57507)
TKk	.245205E-02	.777304E-04
	(.662498)	(.071973)
THh	-.342569E-02	.220805E-02***
	(-.638356)	(1.41009)
α	1.12001*	-.091230*
	(12.1270)	(-3.38527)

Note: 1. Observations: 4,186.

2. Standard errors in ( ).

3. * indicates statistical significance at the 5% level, *** at the 20% level

CHh, CKk, CTHh and CTKk represent canada-specific factors in equation (4.12):

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 TK_i k_i + d_2 TH_i h_i + e_1 CH_i h_i + e_2 CK_i k_i + f_1 CTH_i h_i + f_2 CTK_i k_i + \varepsilon_i \qquad (4.12)$$

As presented in Table 4-6, with RCA as dependent variable, the estimators for THh, TKk, CHh, CKk, CTHh and CTKk are not statistically significant at 10% level. With RSCA as dependent variable, the significance of CHh and CTHh have been improved. THh and CTKk are even statistically significant at 10% level. Due to the heavy weight of the natural resource sector in Canadian economy, the accumulation of physical capital may improve its long-run export performance in a way that will bias toward the physical capital-intensive sectors.

Table 4-6. Panel Data Estimation (plain OLS) of equation (4.12):

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 TK_i k_i + d_2 TH_i h_i + e_1 CH_i h_i + e_2 CK_i k_i + f_1 CTH_i h_i + f_2 CTK_i k_i + \varepsilon_i$$

Variable	RCA Coefficient	RSCA Coefficient
k	.971468*	.570821*
	(3.16168)	(6.37763)
Kk	1.03117*	.432204*
	(5.75976)	(8.28767)
Hk	-.724576*	-.458885*
	(-2.82759)	(-7.43165)
h	-1.22306*	-.936370*
	(4.41643)	(11.7542)
Kh	-1.83976*	-.946189*
	(-6.74868)	(-11.9153)
Hh	1.70426*	1.32126*
	(-3.26710)	(-7.10314)
THh	-.372593E-02	.304613E-02**
	(-.660975)	(1.85510)
TKk	.221596E-02	-.597881E-02
	(.570163)	(-.528107)
CHh	.195093	-.074011
	(.863000)	(-1.12392)
CKk	-.114232	.697022E-02
	(-.730893)	(.153102)
CTHh	-.133416E-02	-.593089E-02
	(-.073427)	(-1.12056)
CTKk	.492456E-02	.604262E-02**
	(.392854)	(1.65485)
α	1.11531*	-.083769*
	(12.003)	(-3.0948)

Note: 1. Observations: 4,186.

2. Standard errors in ( ).

3. * indicates statistical significance at the 5% level, ** at the 10% level.

Equation (4.13) tends to capture Canada-specific, primary sector-specific and dynamic characteristics.

$$RCA_i\,(RSCA_i) = \alpha_i + b_1 k_i + b_2 K_i k_i + b_3 H_i k_i + c_1 h_i + c_2 K_i h_i + c_3 H_i h_i + d_1 TK_i k_i + d_2 TH_i h_i + e_1 CH_i h_i + e_2 CK_i k_i + f_1 CTH_i h_i + f_2 CTK_i k_i + g_1 PRIMARY + g_2 CPRIMARY + \varepsilon_i \quad (4.13)$$

As shown in Table 4-7, the Hechscher-Ohlin theory and the Rybczynski effect still hold at the 5% level. Even the country-specific factors and dynamic aspect are not quite significant, primary sectors still play a very important role in Canadian export performance as a whole. Moreover, accumulation of physical capital has a positive impact on the export performance. The role of human capital is much less clear from the present data.

Table 4-7. Panel Data Estimation (plain OLS) of equation (4.13):

$$RCA_i\,(RSCA_i) = \alpha_i + b_1k_i + b_2\,K_ik_i + b_3\,H_ik_i + c_1h_i + c_2\,K_ih_i + c_3\,H_ih_i + d_1TK_ik_i + d_2TH_ih_i + e_1CH_ih_i + e_2CK_ik_i + f_1CTH_ih_i + f_2CTK_ik_i + g_1PRIMARY + g_2CPRIMARY + \varepsilon_I$$

Variable	RCA Coefficient	RSCA Coefficient
k	.931841*	.568399*
	(3.18214)	(6.58161)
Kk	1.06095*	.432237*
	(6.21710)	(8.58851)
h	-1.21478*	-.945500*
	(-2.94682)	(-7.77712)
Hh	1.76025*	1.32204*
	(4.78590)	(12.1881)
Kh	-1.88823*	-.945731*
	(-7.26619)	(-12.3402)
Hk	-.777492*	-.457832*
	(-3.67657)	(-7.34099)
TKk	.142291E-02	-.632725E-03
	(.384085)	(-.579116)
THh	-.227751E-02	.310195E-02*
	(-.423786)	(1.95714)
CHh	.151035	-.094394***
	(.700858)	(-1.48525)
CKk	-.521883*	-.117970*
	(-3.45637)	(-2.64923)
CTHh	-.487598E-02	-.668694E-02***
	(-.281587)	(-1.30942)
CTKk	.655485E-03	.464329E-02***
	(.054856)	(1.31762)
PRIMARY	.362186*	.016473***
	(9.31522)	(1.43661)
CPRIMARY	2.38054*	.759204*
	(15.4134)	(16.6679)
α	1.08240*	-.078049*
	(12.1859)	(-2.97945)

Note: 1. Observations: 4,186.

2. Standard errors in ( ). * indicates statistical significance at the 5% level, ** at the 10% level, *** at the 20% level.

5. Conclusion

The **factor-proportions theory** developed by Heckscher and Ohlin predicts that countries tend to export goods that are intensive in the factors with which they are relatively abundant. This paper has tried to answer theoretically and empirically the following question: how did Canada's comparative advantage of its manufacturing change with the accumulation of its factors of production from 1970 to 1992?

Based on a dual and general equilibrium approach to international trade developed by Dixit and Norman (1980), Krugman and Helpman (1985) shows that under some conditions, a country will be net exporter of the services of factors of which it has a relatively large share of the world supply, and that every trading country can fully employ its resources, using the techniques of production that are used in the integrated equilibrium. A 2 x 2 x 2 numeric example supports the Heckscher-Ohlin theory and the Rybczynski effect: Canada, which is assumed to be relatively abundant in physical capital, tends to export goods that used intensively physical capital. Increases in the supply of a factor of production systematically shift Canadian production and export structures towards industries that intensively use that factor.

Balassa (1979) introduced the 'Revealed Comparative Advantage' to measure a country's export performance. Using a so-called 'one-pass' procedure, Balassa confirmed that inter-country differences in the structure of exports were in a large part explained by differences in factor endowments. Following his approach, this paper has introduced Canada-specific, sector-specific and time factors into the original Balassa model. Panel estimations using 4,186 observations for the 14 OECD countries show that Canada tends to export goods whose production is relatively intensive in factors of which it has a relatively abundant supply and that increases in Canada's supply of a factor of production have a favourable impact on the export performance of the product whose production uses intensively this factor (see Table 4-2). During the period covered by the data, factors other than resources defined as physical and human capital caused Canada's export performance of its manufacturing to under-perform that of its OECD partners (see Table 4-3). Table 4-4 confirms that Canada's primary sectors occupied and still occupy an importance place in its industrial structure. In the long run, the accumulation of physical capital seems to have positive impact on Canada' export performance, however, the role of human capital is much less positive (see Table 4-5, 6, 7). Application of a new market-based measure of this factor proposed by Dudley and Moenius (2001) reveals that in Canada, human capital per worker has remained virtually unchanged since 1970. As a result, there has emerged a growing labour-quality gap between this country and its principal trading partners.

In 1976, Canada was second in terms of productivity level among the G-7 countries. In 1997, Canada was fifth. Canada is the only country in the G-7 that has not closed its gap relative to the USA in terms of productivity. Canada's manufacturing is more productive than the US in resource-based sectors, sectors in which Canada has a large endowment (see Figure 2-7). If we look at the two fastest-growing sectors in North America – that is, Machinery, Electrical and Electronic Equipment – these are what we call knowledge-based sectors, Canada's productivity is about half that of the US. Even Canada possesses some very competitive companies, such as Nortel Networks, but the fact is that in these sectors overall, Canada is 50% less productive.

Do all these justify the Canadian government's activism in its industrial policy in favor of the high-technology industries? By high-tech industries, we mean industries in which the success of companies depends largely on their ability to keep up with rapid innovations in products or production processes.

Since Canada is natural resource-based country, is it possible to promote both the new industries, in which large physical and human capital are demanded, and the resource-based sectors at the same time? Both the trade model and the empirical results suggest that in Canada, accumulation of physical capital will have positive impact on its primary sectors. Theoretically, accumulation of human capital could shift the physical capital out of its resource-based sectors and deteriorate the development of these sectors. Moreover, the role of human capital is not statistically clear.

Moreover, although high-tech industries are probably high-value added and they produce extra social benefits because of technological spillovers, a general principle is that trade and industrial policy should be targeted specifically on the activity in which the market failure occurs. Thus government's policy should be used with caution and seek to subsidize the generation of knowledge that firms cannot appropriate.

References

Balassa, Bela & L. Bauwens (1988), 'Changing trade patterns in manufactured goods – an econometric investigation', 1988 North Holland.

Balassa, Bela (1979), 'The changing pattern of comparative advantage in manufactured goods', Review of economics and statistics, vol 61, mai 1979, p259-266.

Berman, Eli (2000), 'Does factor-biais technological change stifle international convergence? Evidence from manufacturing', Boston University.

Dixit, A.K. and Norman, V, 'Theory of International Trade: A dual, general equilibrium approach', Cambridge University Press, Cambridge, 1980.

Economic Council of Canada (1992), 'Pulling Together: Productivity, Innovation, and Trade', Ottawa, 6op.

Gera, S, Gu, W and Lee, F.C. (1998), 'Capital-Embodied Technical Change and the Productivity Growth Slowdown in Canada', Industry Canada, Working Paper No 21, 1998.

Hall, R and Jones, C., 'Why Do Some Country Produces So Much More Output Per Worker Than Others?', Quarterly Journal of Economics, vol. 114, 1999.

Heckscher, Eli, 'The Effect of Foreign Trade on the Distribution of Income.' Economisk Tidskrift, vol. 21, 1919.

Helpman, E and Krugman, P, 'Market Structure and Foreign Trade', MIT Press, Cambridge, Mass, 1985.

Laursen, Keld (1998), 'Revealed comparative advantage and alternative as measures of international specialisation', DRUID, W.P no 98-30.

Lavoie, M. and R. Finnie (1996), 'The Accumulation of Technology: A Cross-Cohort Longitudinal Analysis of Recent Engineering Graduates' Human Resources Development Canada, Working Paper (W-96-10 E).

Ohlin, Bertil, 'Interregional and International Trade', Harvard University Press, Cambridge, Mass, 1947.

Pavitt, K., (1991), 'What Makes Basic Research Economically Useful?', Research Policy, vol.20, pp 109-119.

Pohjola, Matti (2000), 'Information technology and economic growth: a cross-country analysis' W.P no 173 U.N.UNIVERSITY.

Romalis, John (2000), 'Factor proportions and the structure of commodity trade', MIT 2000.

Rybczynski, T. M., 'Factor Endowments and Relative Commodity Prices', Economica 22, 1955, pp. 336-341.

Vanek, Jaroslav, 'The Factor Proportion Theory: the N-Factor Case', Kyklos, vol.24, 1968.

Wössman, Ludger (2000), 'Specifying human capital : A review, some extensions, and development effects', Kiel Institute of World Economic.