Productivity Levels and International Competitiveness Between Canada and the United States

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5.1 Introduction

THE PURPOSE OF THIS PAPER is to compare total factor productivity (TFP) levels and international competitiveness between 33 Canadian and U.S. industries. To carry out such comparisons, we first need to construct purchasing power parities (PPPs) for output and inputs by industry. We use bilateral Canada-U.S. commodity price data to construct PPPs for output and intermediate inputs, and estimate PPPs for capital input based on the relative prices of investment goods, taking into account the flow of capital services per unit of capital stock. We then use hourly labour compensation rates, disaggregated by different worker types in the two countries, to estimate labour input PPPs. These PPPs take into account differences in the composition of the output and inputs of the industry under consideration between Canada and the United States, thereby allowing inter-country comparisons of both prices and quantities of output and inputs.

Following Jorgenson and Nishimizu (1978) for comparison between Japan and the United States, we use a translog production function originally introduced by Christensen, Jorgenson and Lau (1971, 1973) to estimate relative TFP levels in Canada and the United States. This framework was used extensively by Jorgenson and his associates, including Jorgenson, Kuroda and Nishimizu (1987), Jorgenson and Kuroda (1995), and Kuroda and Nomura (1999). Following that tradition, relative TFP levels can be assumed to reflect differences in technology levels since the quality of inputs is already taken into account in this framework.

Based on a common framework using comparable data sets for Canada and the United States,[1] our results show that in 1995, 23 of 33 Canadian industries had lower TFP levels than their U.S. counterparts.[2] Our results also suggest that the relative TFP level is an important element of international competitiveness across industries. In fact, Canadian industries with higher TFP levels than their U.S. counterparts tend to be more competitive in terms of relative output prices. Over time, however, movements in the exchange rate appear to be the most significant factor behind international competitiveness.

From 1988 to 1995, the depreciation of the exchange rate helped 9 industries become more competitive than their U.S. counterparts. In addition, movements in the exchange rate coincided with movements in the relative output prices of the private business sector in the two countries over the 1961-95 period. Focusing on a more recent period, that between 1976 and 1995, Canada's private business sector saw its competitiveness improve relative to that of the U.S. business sector, even as its TFP performance was not improving — although a slight rebound has occurred in that respect since 1993.

The remaining sections of the chapter are organized as follows. In Section 5.2, we construct PPPs for output and inputs, while Sections 5.3 and 5.4 are devoted to a comparison of TFP levels and international competitiveness between Canadian and U.S. industries. In Section 5.5, we discuss the evolution of TFP and competitiveness in the Canadian and U.S. private business sectors. We conclude our study in Section 5.6.

5.2. Purchasing Power Parities for Output and Inputs

IN THIS SECTION, WE DISCUSS the data and methodology used in constructing Canada-U.S. bilateral PPPs for output and inputs in 33 industries. In this context, it is useful to keep in mind that the value of output is defined from the producer's point of view and the value of inputs, from the producer-purchaser's standpoint. This has implications for constructing PPPs, as will be seen later.

First, we group the 1992 Canadian and U.S. input-output tables[3] into 249 common commodity groups and 33 industries.[4] We then match 201 commodity PPPs[5] at purchasers' prices with commodities in the I-O tables. Among the remaining 48 commodities in the I-O tables, we first identify 26 that have close substitutes among the 201 commodities already matched, and then apply to them the PPPs of their close substitutes. In the case of the remaining 22 commodities, we use the 1993 market exchange rate. These commodities are mainly primary goods (such as grain, wheat, copper, steel, and precious metals) that are heavily traded in North American or world markets. The 249 PPPs and the I-O tables are used to develop PPPs for output and inputs other than labour.[6]

5.2.1 Purchasing Power Parities for Output

The output PPP is defined as the ratio of the amount of Canadian dollars received by Canadian producers for output sold in Canada, to the amount of U.S. dollars received by U.S. producers for selling the same amount of output in the United States. Thus output PPPs are at producers' prices, implying that we first need to convert commodity PPPs at purchaser's prices, $EPPP_j$, into commodity PPPs at producers' prices, PPP_j, by "peeling off" tax and distribution margins (the indirect commodity tax margin and the transportation and trade margins), using the I-O tables of both countries.[7]

We then proceed to construct output PPPs for each industry. The output PPP in industry i is obtained by aggregating 249 commodity PPPs in translog form, using nominal shares in the commodity mix as weights for industry i:

$$\text{(1)} \qquad \ln(PPP_i^Q) = \sum_{j=1}^{249} 1/2 \left[v_{i,j}^Q(Can) + v_{i,j}^Q(US) \right] \cdot \ln(PPP_j),$$

where $v_{i,j}^Q(S)$ is the value share of commodity j in industry i in country S, estimated from the *make* matrices of the I-O tables.

5.2.2 Purchasing Power Parities for Intermediate Inputs

Intermediate inputs include energy, materials, and purchased services. Their PPPs are computed in the same manner as output PPPs, but they are based on commodity PPPs at purchasers' prices, which include tax, transportation, and trade margins. With this in mind, the PPP for intermediate inputs in industry i is defined as the translog aggregate of the 249 commodity PPPs:

$$\text{(2)} \qquad \ln(PPP_i^M) = \sum_{j=1}^{249} 1/2 \left[v_{i,j}^M(Can) + v_{i,j}^M(US) \right] \cdot \ln(EPPP_j),$$

where $v_{i,j}^M(S)$ is the value share of goods (or services) of type j that are used as intermediate inputs in industry i in country S, estimated from the *use* matrices of the I-O tables. Here, $EPPP_j$, is the PPP at purchasers' prices for commodity j as defined earlier.

5.2.3 Purchasing Power Parities for Capital Input

As in Chapter 4, capital input is broken down here into four asset types — machinery and equipment (M&E), non-residential structures, inventories, and land. However, the price data available only allow us to construct investment PPPs for M&E and structures. Following Jorgenson and Kuroda (1995), and Kuroda and Nomura (1999), we aggregate 249 commodity PPPs to construct investment PPPs for new investment type k (M&E or structures) in industry i from the purchasers' standpoint:

(3) $$\ln(PPP^{I}_{i,k}) = \sum_{j=1}^{249} 1/2\left[v^{I}_{i,k,j}(Can) + v^{I}_{i,k,j}(US)\right] \cdot \ln(EPPP_j),$$

where $v^{I}_{i,k,j}(S)$ is the value share of investment good j of type k in industry i, estimated from the *investment flow* matrices of the I-O tables.

We then derive a capital input PPP for each type (M&E and structures) in industry i by multiplying the ratio of each type's rental price for Canada relative to the United States by its corresponding investment PPP,

(4) $$PPP^{K}_{i,k} = \left(\frac{P^{K}_{i,k}(Can)/P^{I}_{i,k}(Can)}{P^{K}_{i,k}(US)/P^{I}_{i,k}(US)}\right) PPP^{I}_{i,k},$$

where $P^{K}_{i,k}(S)$ is the capital input price of asset type k in country S, while $P^{I}_{i,k}(S)$ is the investment price index for that asset type. For each asset type, the ratio of the capital input price to the investment price index is the rental price of capital input of this asset type. As described in previous chapters, the rental price of capital input is estimated by taking account of the rate of return on capital, economic depreciation rates, and various tax parameters in each country. Thus, in deriving capital input PPPs, we implicitly assume that the relative efficiency of new capital goods in a given industry is the same in both countries. However, the decline in the efficiency of capital input for each component is estimated separately for each country.

We assume that the capital input PPP for land is the same as that for structures. Furthermore, we assume that the capital input PPP for inventories is the same as the weighted average of capital input PPPs for M&E, structures and land. The total capital input PPPs in this paper are then derived by aggregating individual capital input PPPs across p types of capital input (M&E,

structures, land, and inventories), using the average compensation in the two countries for each type of capital input as weights:

$$(5) \qquad \ln(PPP_i^K) = \sum_{k=1}^{p} 1/2\left[v_{i,k}^K(Can) + v_{i,k}^K(US)\right] \cdot \ln(PPP_{i,k}^K),$$

where $v_{i,k}^K(S)$ is the capital compensation share of type k capital in industry i in country S.

5.2.4 Purchasing Power Parities for Labour Input

For each of the 33 industries, labour inputs in Canada and the United States are matched by sex, employment status, age, and education, as shown in Table 5.1. We estimate the labour input PPP for industry i by aggregating the ratio of hourly labour compensation rates between the two countries over q types (112) of labour:

$$(6) \qquad \ln(PPP_i^L) = \sum_{l=1}^{q} \left\{ 1/2\left[v_{i,l}^L(Can) + v_{i,l}^L(US)\right] \cdot \ln\left[\frac{P_{i,l}^L(Can)}{P_{i,l}^L(US)}\right] \right\},$$

where $P_{i,l}^L(S)$ is the average labour compensation per hour of type l worker in industry i in country S, and $v_{i,l}^L(S)$ is the total labour compensation share for that worker type.

Table 5.1
Classification of the Canadian and U.S. Workforce

Worker Characteristics	Number of Categories	Type
Sex	2	Female; Male
Employment Category	2	Paid Employees; Self-employed[1]
Age	7	16-17;[2] 18-24; 25-34; 35-44; 45-54; 55-64; 65+
Education	4	0-8 Years Grade School; Some or Completed High School; Some or Completed Post-Secondary School; University or Higher

Notes: [1] U.S. self-employed includes unpaid workers.
[2] The age group is 15-17 for Canada.

5.2.5 Summary of Purchasing Power Parities Between Canada and the United States, 1993

PPPs for output and three types of inputs in 1993 are reported in Table 5.2.[8] The output PPPs are generally in line with the exchange rate (1.29 in 1993) for most industries. However, for coal mining, tobacco, and electric utilities, they are on the lower side.

Capital input PPPs are highly variable across industries. These variations stem from the variations in the rental prices of capital input between the two countries since capital investment prices are generally comparable. For instance, the rental price of capital input in the motor vehicles, rubber and plastics, and industrial machinery industries is higher in Canada than in the United States, while the opposite is true in the paper and allied products, petroleum refining, and other services industries. The higher rental price of capital input in other services in the United States is mainly due to a higher rental price in private education and legal services in that country than in Canada. A close examination reveals that the substantial differences in the rental prices of capital input noted between Canada and the United States are attributable to large differences in the capital compensation figures from the two countries' I-O tables relative to their respective capital stocks.

With respect to the PPPs for labour input, we first observe that variations across industries are very small. In addition, labour input PPPs are below unity for 17 industries, which is significantly below the exchange rate.

Finally, intermediate input PPPs are fairly constant across industries and more or less equal to the exchange rate for all industries except tobacco. The Canadian tobacco industry pays a higher price for intermediate inputs than does its U.S. counterpart, mainly because of the difference in the taxation on semi-finished tobacco products between the two countries.

Table 5.2

Purchasing Power Parities by Industry, 1993 (U.S. = 1.00)

Industry	Output	Capital Input	Labour Input	Intermediate Inputs
1. Agric., For. and Fisheries	1.35	1.93	0.62	1.35
2. Metal Mining	1.29	1.70	1.06	1.27
3. Coal Mining	0.88	0.99	0.88	1.29
4. Crude Pet. and Gas	1.45	1.09	1.02	1.26
5. Non-met. Mining	1.35	1.82	1.04	1.29
6. Construction	1.13	2.08	1.13	1.34
7. Food	1.42	2.13	1.11	1.36
8. Tobacco	0.74	2.23	1.05	1.57
9. Textile	1.46	2.36	1.06	1.35
10. Apparel	1.34	2.29	0.96	1.38
11. Lumber and Wood	1.25	1.88	1.21	1.24
12. Furniture	1.36	2.41	0.93	1.35
13. Paper	1.55	0.75	1.16	1.30
14. Printing	1.52	2.45	1.12	1.35
15. Chemicals	1.28	1.19	0.81	1.32
16. Petroleum Refining	1.13	0.47	0.99	1.29
17. Rubber and Plastics	1.58	2.73	1.02	1.31
18. Leather	1.32	0.83	1.06	1.27
19. Stone, Clay and Glass	1.41	2.08	1.01	1.32
20. Primary Metals	1.28	1.10	1.07	1.26
21. Fabricated Metals	1.40	1.85	0.89	1.29
22. Industrial Machinery	1.30	2.55	0.85	1.28
23. Electrical Machinery	1.17	1.70	0.92	1.23
24. Motor Vehicles	1.23	3.59	0.76	1.35
25. Other Trans. Equip.	1.35	2.19	0.97	1.31
26. Misc. Manufacturing	1.29	2.40	0.80	1.30
27. Trans. and Warehousing	1.33	1.60	0.85	1.29
28. Communications	1.18	1.23	0.93	1.23
29. Electric Utilities	0.90	1.15	1.12	1.19
30. Gas Utilities	1.30	1.95	0.86	1.26
31. Trade	1.19	1.60	1.05	1.29
32. Finance, Ins. and Real Estate	1.32	2.05	0.81	1.24
33. Other Services	1.08	0.37	0.98	1.25
Private Business	1.22[1]	1.23	0.96	

Note: [1] For value added from Statistics Canada's Canada-U.S. GDP purchasing power parity.

5.3 Relative Productivity Levels

BASED ON THE PPPS CONSTRUCTED ABOVE, we estimate relative TFP levels between Canada and the United States for 33 industries.[9] As Jorgenson and Nishimizu (1978) for the comparison between Japan and the United States, our theoretical framework for this comparison is based on a translog production function originally introduced by Christensen, Jorgenson, and Lau (1971, 1973). Here, output is a translog function of capital input, labour input, and intermediate inputs, as well as a dummy variable equal to one for Canada and zero for the United States, and time as an index of technology for each industry. However, as did Jorgenson and Kuroda (1995), and Kuroda and Nomura (1999), we find that it is more convenient to work with the dual price function of output to analyse international competitiveness and relative TFP levels. The dual price function is derived from the production function under competitive conditions. The price function for the *i*th industry can be represented as:

$$\begin{aligned} \ln P_i = {} & \ln P_i^{X'} \alpha_i^X + \alpha_i^t t + \alpha_i^D D + 1/2 \ln P_i^{X'} \beta_i^{XX} \ln P_i^X + \ln P_i^{X'} \beta_i^{Xt} t \\ & + \ln P_i^{X'} \beta_i^{XD} D + 1/2\, \beta_i^{tt} t^2 + \beta_i^{tD} tD + 1/2\, \beta_i^{DD} D^2, \end{aligned} \tag{7}$$

where P_i is the output price of the *i*th industry; $\ln P_i^X$ denotes $\{\ln P_i^K \ln P_i^L \ln P_i^M\}$, a vector of logarithms of capital input price (P_i^K), the labour input price (P_i^L), and the intermediate input price (P_i^M) of the *i*th industry; t denotes time as an index of technology; and D is a dummy variable, equal to one for Canada and zero for the United States.

In this presentation, scalars $\{\alpha_i^t, \alpha_i^D, \beta_i^{tt}, \beta_i^{tD}, \beta_i^{DD}\}$, the vectors $\{\alpha_i^X, \beta_i^{Xt}, \beta_i^{XD}\}$, and the matrix $\{\beta_i^{XX}\}$ are constant parameters. However, these parameters differ among industries, reflecting differences among technologies. Within each industry, differences in technology among time periods are represented by time as an index of technology. Differences in technology between Canada and the United States are associated with the dummy variable.

Based on the above price function, Jorgenson and Kuroda (1995), and Kuroda and Nomura (1999) show that differences in the logarithms of the TFP levels between Canada and the United States, $\overline{v}_i^D$ can be expressed as the negative value of the differences between the logarithms of the output prices, less a weighted average of the differences between the logarithms of input prices,

$$(8) \qquad \bar{v}_i^D = -\left\{ \ln\left[\frac{P_i(Can)}{P_i(US)}\right] - \bar{v}_i^K \ln\left[\frac{P_i^K(Can)}{P_i^K(US)}\right] - \bar{v}_i^L \ln\left[\frac{P_i^L(Can)}{P_i^L(US)}\right] - \bar{v}_i^M \ln\left[\frac{P_i^M(Can)}{P_i^M(US)}\right] \right\},$$

where $\bar{v}_i^j = 1/2\left[v_i^j(Can) + v_i^j(US)\right]$, the average compensation share of input j in Canada and the United States for the ith industry. The price ratios in the above equation are the PPPs for output and inputs.

We first calculate 1993 relative TFP levels in Canada and the United States for 33 industries based on the estimated 1993 PPPs using Equation (8). We then use the TFP indices constructed in the previous chapter to estimate relative TFP levels in other years. The estimated relative TFP levels by industry are reported in Table 5.3. In 1995, Canada was less productive than the United States in 23 of the 33 industries. In particular, Canada was much less productive in agriculture, forestry and fisheries; crude petroleum and gas; paper; printing; rubber and plastics; leather; stone, clay, and glass; fabricated metals; industrial machinery; and transportation and warehousing. On the other hand, in 1995 Canada was significantly more productive than the United States in coal mining, construction, tobacco, petroleum refining, electric utilities, and gas utilities.

To examine the trend in relative TFP levels in Canadian and U.S. industries, we estimated the variance of relative TFP levels by industry for the period 1961-95. As shown in Figure 5.1, the variance for all industries declined dramatically in the 1960s. After 1970, however, it remained fairly stable. This implies that TFP performance in Canada and the United States converged across industries during the 1960s. Indeed, in 19 of the 25 industries where Canada lagged behind the United States with respect to TFP levels in 1961, Canada improved its relative TFP performance from 1961 to 1973; the largest improvements were in those industries where TFP gaps were the widest (coal mining and communications). At the same time, Canada lost some of its relative TFP advantage in 2 industries (tobacco and petroleum refining) where that advantage was the largest in 1961. Between 1973 and 1988, the variance remained more or less steady. Over this period, some low-productivity Canadian industries were catching up to their U.S. counterparts, but their relative gains were modest. At the same time, these gains were offset by U.S. industries catching up to highly productive Canadian industries (metal mining, petroleum refining, and both machinery industries). Over the 1988-95 period, the variance of the relative TFP gap between the two countries decreased. Most of the decline can be attributed to U.S. industries (such as metal mining, coal mining, and electrical machinery) catching up to, and in some instances surpassing, the TFP levels of Canadian industries. Meanwhile, most Canadian industries that were less productive than their U.S. counterparts either were unable to catch up to U.S. TFP levels or only made modest gains.

To give another perspective on this issue, we also examined the number of Canadian industries that were less productive than their U.S. counterparts. That number decreased from 20 in 1961 to 17 in 1973, as shown in Table 5.3. However, it rose to 21 in 1988 and 23 in 1995. Thus the number of Canadian industries that were less productive than their U.S. counterparts has increased since 1973. These numbers provide a snapshot of performance in a given year, but they do not help to assess the improvement or deterioration of Canada's relative TFP performance over time.

Figure 5.1
Variance of the Productivity Gap (in Logs) Among Industries

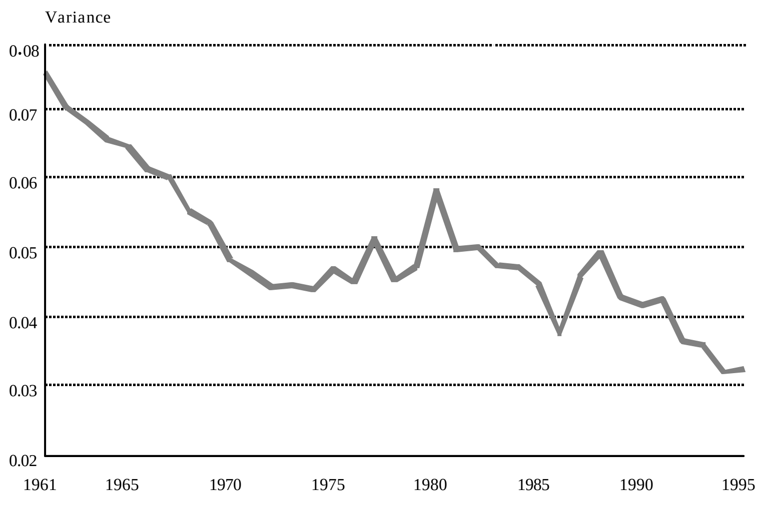


Table 5.3
TFP Levels in Canada Relative to the United States, (U.S. = 1.00)

Industry	1961	1973	1988	1995
1. Agric., For. and Fisheries	0.87	0.98	0.89	0.83
2. Metal Mining	1.44	1.55	1.34	0.90
3. Coal Mining	0.77	1.15	1.50	1.16
4. Crude Pet. and Gas	0.83	1.01	0.62	0.71
5. Non-met. Mining	0.87	0.95	0.98	0.96
6. Construction	0.87	0.93	1.11	1.18
7. Food	1.15	1.13	0.97	0.96
8. Tobacco	1.75	1.60	2.06	2.06
9. Textile	1.09	1.23	1.03	0.98
10. Apparel	1.06	1.08	1.00	0.99
11. Lumber and Wood	0.79	0.90	0.91	1.01
12. Furniture	1.00	1.14	0.92	0.96
13. Paper	0.91	0.84	0.81	0.83
14. Printing	0.86	0.86	0.95	0.88
15. Chemicals	0.82	0.80	0.89	0.93
16. Petroleum Refining	1.39	1.30	1.09	1.15
17. Rubber and Plastics	0.85	0.91	0.86	0.85
18. Leather	0.71	0.82	0.85	0.83
19. Stone, Clay and Glass	0.86	1.01	0.95	0.87
20. Primary Metals	0.90	0.96	0.96	0.96
21. Fabricated Metals	0.81	0.85	0.84	0.84
22. Industrial Machinery	1.11	1.21	0.95	0.88
23. Electrical Machinery	1.26	1.31	1.15	0.98
24. Motor Vehicles	0.73	0.93	1.04	1.07
25. Other Trans. Equip.	1.02	0.98	0.89	0.98
26. Misc. Manufacturing	1.09	1.07	0.90	0.92
27. Trans. and Warehousing	0.82	0.90	0.94	0.87
28. Communications	0.39	0.61	0.94	0.99
29. Electric Utilities	1.51	1.57	1.61	1.24
30. Gas Utilities	0.81	1.24	1.36	1.15
31. Trade	0.80	0.94	1.08	1.02
32. Finance, Ins. and Real Estate	1.29	1.15	0.92	1.09
33. Other Services	0.90	0.86	0.93	0.93

We now turn to that issue. When we examine the performance of relative TFP levels over time, the pervasiveness of the decline in Canada becomes evident. From 1961 to 1973, only 9 Canadian industries experienced a decline in TFP relative to their U.S. counterparts. However, that number rose to 16 between 1973 to 1988 and to 17 between 1988 to 1995. In summary, the deterioration of Canada's TFP levels relative to those of the United States has become more widespread across industries since 1973.

5.4 Competitiveness in Canadian and U.S. Industries

THIS SECTION ASSESSES DIFFERENCES IN COMPETITIVENESS between Canadian and U.S. industries and links these differences to their relative TFP levels. Following Jorgenson and Kuroda (1995), we measure competitiveness by relative output prices, defined as output PPPs divided by the exchange rate ($CDN per $US).

To facilitate our analysis, we decompose relative output prices into relative TFP levels and relative capital, labour, and intermediate input prices. We rearrange Equation (8) and divide each price ratio by the exchange rate:

$$(9) \qquad \ln RP_i = -\bar{v}_i^D + \bar{v}_i^K \ln RP_i^K + \bar{v}_i^L \ln RP_i^L + \bar{v}_i^M \ln RP_i^M ,$$

where RP_i is the relative price of output; $\bar{v}_i^D$ is the TFP gap between Canada and the United States for industry i; and RP_i^K, RP_i^L, and RP_i^M are the relative prices of capital, labour, and intermediate inputs, respectively.

The relative prices for output, for capital, labour, and intermediate inputs, and for relative TFP levels in 1995 are reported in Table 5.4. In 1995, more than half of Canadian industries had a lower relative output price than their U.S. counterparts.

With respect to capital input, Canada had higher capital input prices than the United States in 27 industries. In particular, Canadian capital input prices were substantially higher than U.S. prices in metal mining, textiles, apparel, furniture, paper, rubber and plastics, primary metals, motor vehicles, other transportation equipment, and miscellaneous manufacturing in 1995. However, in some Canadian industries — such as coal mining, crude petroleum and natural gas, leather, and other services — capital input prices were lower than in the corresponding U.S. industries. As discussed earlier, it is helpful to keep in mind that differences in relative capital input prices reflect differences not only in capital investment prices but also in the rental price of capital input.

In contrast with the situation regarding capital input prices, all Canadian industries had an advantage over their U.S. counterparts in terms of labour costs, and the variations in relative labour input prices across industries were very small in 1995. As a result of this difference in labour costs, the industrial structures of the two countries are also different. Canadian industries are generally more labour-intensive, while U.S. industries tend to be more capital-intensive. This is evident when we compare capital intensity (the ratio of capital stock to hours) of the two countries. For instance, in 1993, capital intensity in Canada (capital stock PPP-based) was only 79 percent that of the United States.[10]

Finally, most Canadian industries paid almost the same price for their intermediate inputs as did their U.S. counterparts.

When examining the links between competitiveness, relative TFP levels, and relative input prices, a simple correlation among these variables is a good starting point for discussion. The correlation coefficient between relative output prices and relative TFP levels is –0.69 based on 1995 data, while in the case of capital, labour, and intermediate inputs, the coefficients stand at 0.47, 0.16, and 0.12, respectively. These coefficients indicate that variations in relative output prices across industries are strongly related to inter-industry differences in relative TFP levels.

We summarize the relationship between output prices and TFP levels by plotting relative output prices against relative TFP levels for 1995 across industries in Canada and the United States, as shown in Figure 5.2. To better illustrate the relationship between competitiveness and relative TFP levels, we divide the figure into four quadrants. In quadrants I and II are found those Canadian industries which are less competitive than their U.S. counterparts, while quadrants III and IV show Canadian industries that are more competitive than their U.S. equivalents. At the same time, Canadian industries in quadrants II and III are more productive than their U.S. competitors, while relatively less productive industries in Canada are located in quadrants I and IV.

Table 5.4

Relative Prices* and TFP Levels by Industry, 1995 (U.S. = 1.00)

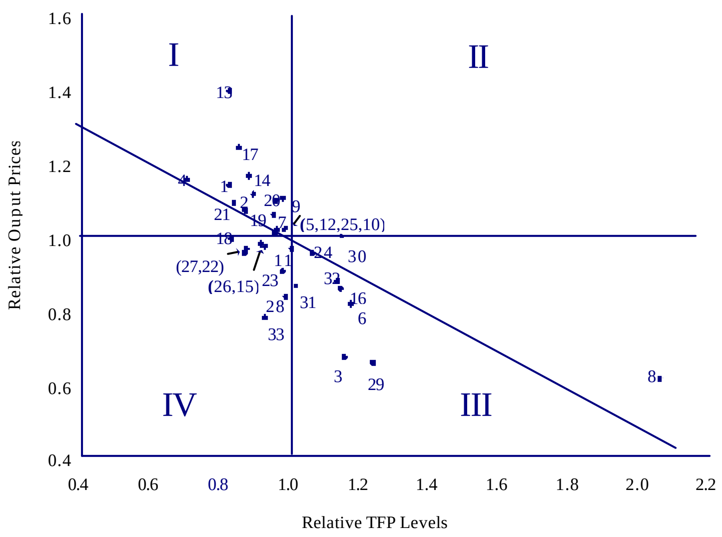
Industry	Output	TFP	Capital Input	Labour Input	Intermediate Inputs
1. Agric., For. and Fisheries	1.13	0.83	1.76	0.56	1.03
2. Metal Mining	1.11	0.90	2.07	0.68	0.91
3. Coal Mining	0.67	1.16	0.70	0.66	0.99
4. Crude Pet. and Gas	1.15	0.71	0.76	0.80	0.91
5. Non-met. Mining	1.00	0.96	1.31	0.69	0.96
6. Construction	0.81	1.18	1.31	0.83	1.00
7. Food	1.05	0.96	1.21	0.78	1.03
8. Tobacco	0.61	2.06	1.74	0.69	1.29
9. Textile	1.10	0.98	3.26	0.77	1.05
10. Apparel	1.01	0.99	2.34	0.72	1.05
11. Lumber and Wood	0.96	1.01	1.20	0.98	0.92
12. Furniture	1.01	0.96	3.17	0.67	1.01
13. Paper	1.39	0.83	2.99	0.84	1.07
14. Printing	1.16	0.88	1.96	0.80	1.05
15. Chemicals	0.97	0.93	1.01	0.59	1.01
16. Petroleum Refining	0.85	1.15	1.21	0.75	0.99
17. Rubber and Plastics	1.23	0.85	2.20	0.79	1.04
18. Leather	0.99	0.83	0.48	0.72	1.01
19. Stone, Clay and Glass	1.06	0.87	1.49	0.71	0.95
20. Primary Metals	1.09	0.96	2.24	0.79	1.05
21. Fabricated Metals	1.08	0.84	1.54	0.66	0.98
22. Industrial Machinery	0.96	0.88	1.12	0.64	0.96

Table 5.4 (cont'd)

Industry	Output	TFP	Capital Input	Labour Input	Intermediate Inputs
23. Electrical Machinery	0.90	0.98	1.35	0.64	0.92
24. Motor Vehicles	0.95	1.07	3.50	0.56	1.02
25. Other Trans. Equip.	1.01	0.98	2.70	0.70	1.02
26. Misc. Manufacturing	0.97	0.92	2.48	0.55	1.00
27. Trans. and Warehouse	0.95	0.87	1.10	0.64	0.93
28. Communications	0.83	0.99	0.91	0.66	0.89
29. Electric Utilities	0.65	1.24	0.75	0.79	0.87
30. Gas Utilities	0.99	1.15	1.56	0.59	0.95
31. Trade	0.86	1.02	1.47	0.76	0.89
32. Finance, Ins. and Real Estate	0.88	1.09	1.51	0.64	0.87
33. Other Services	0.77	0.93	0.32	0.73	0.88

Note: * PPP rates divided by the exchange rate.

Figure 5.2
Relative Output Prices Against Relative TFP Levels, 1995 (U.S. = 1.00)



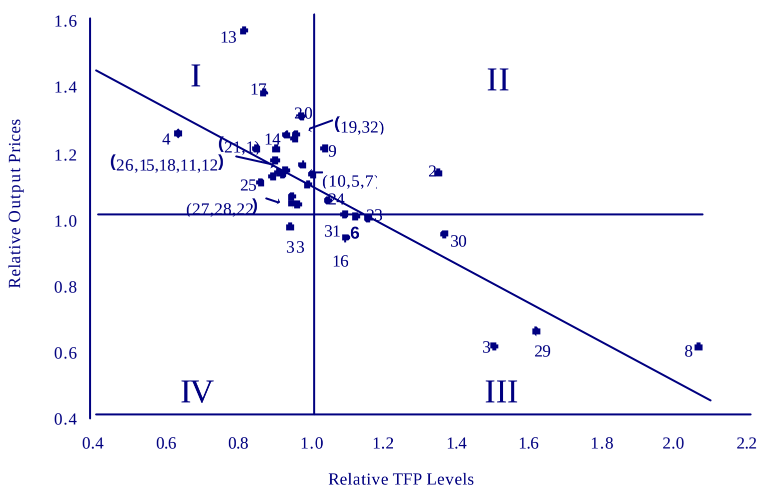
Note: The numbers in this figure refer to those industries listed in Table 5.2.

In 1995, 15 Canadian industries were less competitive and less productive than the corresponding U.S. industries (quadrant I). In 7 industries (food, textiles, apparel, paper, printing, rubber and plastics, and primary metals), lower productivity combined with higher input prices (affecting all three types of inputs) to reduce competitiveness. Low input prices in 6 of the remaining industries were not strong enough to offset the effects of lower productivity and make these industries more competitive. No industry was less competitive but more productive than its U.S. counterpart (quadrant II).

An examination of quadrant III reveals that 10 Canadian industries were more competitive and more productive than the corresponding U.S. industries. Seven of these — coal mining; construction; lumber and wood; petroleum refining; electric utilities; finance, insurance, and real estate (FIRE); and trade — were identified as having relatively lower input prices than their U.S. counterparts. The remaining 3 industries — tobacco, gas utilities, and motor vehicles — had higher input prices than their U.S. competitors, but the difference was not large enough to make them less competitive than the U.S. industries.

Finally, quadrant IV shows the industries where Canada was more competitive but less productive than the United States — chemicals; leather; industrial machinery; electrical machinery; miscellaneous manufacturing; communications; transportation and warehousing; and other services. Canada's competitive position in those cases stemmed from lower input prices rather than higher TFP levels. Thus, it appears that the main factor behind variations in international competitiveness across industries is the gap in relative TFP levels.

Figure 5.3
Relative Output Prices Against Relative TFP Levels, 1988 (U.S. = 1.00)



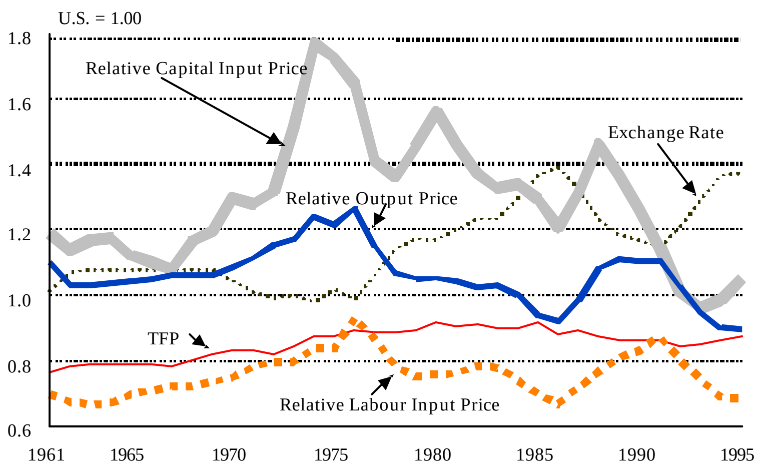
Note: The numbers in this figure refer to those industries listed in Table 5.2.

However, movements in international competitiveness over time are strongly influenced by variations in the exchange rate through relative input prices. For the purpose of illustration, we compare international competitiveness between 1988 and 1995. We plot relative output prices against relative TFP levels for 1988, as shown in Figure 5.3, to facilitate the discussion. In 1988, only 8 Canadian industries were more competitive than their U.S. counterparts, compared to 18 industries in 1995. This change is explained by the fact that the Canadian dollar depreciated by more than 10 percent during the intervening period. If the exchange rate in 1995 had remained at its 1988 level, only 9 Canadian industries would have been more competitive than their U.S. counterparts that year. In addition, several Canadian industries — lumber and wood, chemicals, leather, industrial machinery, motor vehicles, miscellaneous manufacturing, transportation and warehousing, and communications — would have lost ground and become less competitive than their U.S. counterparts by 1995.

5.5 Canada-U.S. Differences in Productivity and International Competitiveness in the Private Business Sector

IN THIS SECTION, we examine the relative performance of the Canadian and U.S. private business sectors with respect to TFP levels and competitiveness over the 1961-95 period.[11] We plot relative TFP levels, relative output and input prices, as well as the exchange rate in Figure 5.4.

Figure 5.4
Relative Productivity and Competitiveness Between Canada and the United States in the Private Business Sector



The results show that Canada's TFP levels were catching up to U.S. levels, rising from 76 percent of the U.S. level in 1961 to almost 92 percent in 1980. However, the gap between the two countries began to widen after 1985 and stood at 12 percent in 1995.

Meanwhile, Canada's relative competitive position worsened between 1963 and 1976. This deterioration would have been much worse without the improvements in relative TFP levels that occurred in the Canadian business sector over this period. Canada's competitive position then improved from 1976 to 1995, not as a result of TFP improvements but of the Canadian dollar depreciation through its impact on relative input prices.

Relative labour prices tend to be in line with relative output prices. Despite the volatility associated with the exchange rate, labour costs were consistently lower in Canada than in the United States over the 35-year period 1961-1995. In addition, the trend was fairly stable over that period. In contrast, relative capital input prices have been much more volatile. Since 1975, relative capital input prices have declined, in line with the depreciation of the Canadian dollar. In general, however, they have remained higher in Canada than in the United States, except in 1993 and 1994.

5.6 Summary and Conclusion

THIS STUDY ILLUSTRATES that it is critical to use PPPs rather than the market exchange rate to assess the relative productivity levels and international competitiveness of two countries. PPPs vary across industries and types of output and inputs. Based on a common framework and using comparable data sets, 23 of 33 Canadian industries had lower TFP levels compared to their U.S. counterparts in 1995. Relative TFP levels are an important element in determining international competitiveness. Our analysis indicates that Canadian industries with high relative productivity compared to their U.S. counterparts tend to be more competitive. Over time, however, movements in the exchange rate appear to be the most significant factor behind international competitiveness. From 1988 to 1995, the falling exchange rate helped 9 Canadian industries become more competitive than their U.S. counterparts.

Our analysis of the private business sector reinforces our findings at the industry level showing that movements in the exchange rate coincide with variations in relative output prices. Over the 1976-95 period, during which the competitiveness of Canada's private business sector improved relative to that of the U.S. private business sector, Canada's relative TFP performance did not improve, despite a slight rebound after 1993.

This study is a first step towards understanding the differences in productivity and international competitiveness between Canada and the United States. A number of refinements could prove fruitful. First, it would be useful to collect more data comparing prices between Canada and the United States in order to increase the reliability of PPP estimates. A second avenue would be to expand capital asset categories for Canada to match Jorgenson's categories for the United States or those of the U.S. Bureau of Labor Statistics. Future research may also benefit from an assessment of the comparability of the two countries' I-O tables, with a special focus on capital compensation data.

Notes

1 A description of the data is provided in the last chapter.

2 See Chapter 4 for data sources.

3 The I-O tables for both countries include make, use, final demand, and investment flow matrices.

4 The Canadian I-O tables are aggregated from 479 commodities and 170 industries; the U.S. tables are aggregated from 541 commodities and 541 industries.

5 These are 1993 PPPs, aggregated on the basis of data pertaining to more than 2,000 commodities obtained from Statistics Canada. Statistics Canada uses the data to estimate a bilateral GDP PPP between Canada and the United States.

6 Although these 249 commodities cover all commodities in the I-O tables, some of them may not be used as inputs. In that case, they are not entered into the calculation of input PPPs.

7 Hooper and Vrankovich (1995) adjust commodity PPPs for international trade in constructing output PPPs. Our analysis shows that incorporating this methodology does not significantly change the results since it is based on two restrictive assumptions: both export and import prices equal world prices; and world prices equal the average of the prices in the two countries, weighted by their expenditures. Since we are unable to justify these two assumptions, we use output PPPs without international trade adjustments.

8 The output PPP for the private business sector is approximated by the bilateral value-added PPP for the total economy, as calculated by Statistics Canada.

9 An assessment of the implications of quality adjustments to capital and labour inputs for estimating relative TFP levels is found in the Annex of this chapter.

10 Canada's capital intensity is based on an alternative set of capital stock estimates produced by the Investment and Capital Stock Division of Statistics Canada. These alternative capital stock estimates are based on the same declining-balance rates as those used in the United States. Capital intensity for Canada would be much lower if we used capital stock data from Statistics Canada's KLEMS database (see details in Appendix G).

11 The aggregate price function gives the value-added price as a function of capital and labour input prices, so that the intermediate input price is excluded. Similar to Equation (8), the difference in the logarithms of the TFP levels between the Canadian and U.S. private business sectors can be expressed as the negative value of the difference between the logarithm of the value-added price and the weighted average of the difference between the logarithms of capital and labour input prices.

Annex:
Quality of Capital and Labour Inputs and Relative TFP Levels

IN THIS ANNEX, WE FIRST COMPARE relative levels of capital and labour input quality in Canada and the United States and assess their implications for relative TFP levels. Following Dougherty (1992), we estimate relative capital input levels (PPP-adjusted) for Canada and the United States, with each country's asset type (M&E, structures, land, and inventories) weighted by the average compensation share in the two countries:

(A-1) $$\ln\left[K_i(Can)/K_i(US)\right]=\sum_{k=1}^{4}1/2\left[v_{i,k}^{K}(Can)+v_{i,k}^{K}(US)\right]\ln\left[A_{i,k}(Can)/A_{i,k}(US)\right].$$

Here, $K_i(S)$ denotes capital input in industry i in country S, $v_{i,k}^{K}(S)$ is the capital compensation share of type k capital asset in total capital compensation in industry i in country S, and $A_{i,k}(S)$ is the net stock of type k capital asset in industry i in country S. We then use the following expression to estimate relative capital quality levels for Canada and the United States:

(A-2) $$\ln\left[q_i^k(Can)/q_i^k(US)\right]=\ln\left[K_i(Can)/K_i(US)\right]-\ln\left[A_i(Can)/A_i(US)\right],$$

where $A_i(S)=\sum_{k=1}^{4}A_{i,k}(S)$ denotes the total capital stock in industry i in country S.

Likewise for capital input, relative labour input levels in Canada and the United States for industry i can be expressed as:

(A-3) $$\ln\left[L_i(Can)/L_i(US)\right]=\sum_{j=1}^{112}1/2\left[v_{i,j}^{L}(Can)+v_{i,j}^{L}(US)\right]\ln\left[H_{i,j}(Can)/H_{i,j}(US)\right],$$

where $v_{i,j}^{L}(S)$ denotes the labour compensation shares of type j workers in industry i in country S, and $H_{i,j}(S)$ denotes the hours worked by workers of type j in industry i in country S. As with capital quality, relative labour quality levels are estimated by the following expression:

(A-4) $$\ln\left[q_i^L(Can)/q_i^L(US)\right]=\ln\left[L_i(Can)/L_i(US)\right]-\ln\left[H_i(Can)/H_i(US)\right],$$

where $H_i(S)=\sum_{j=1}^{112}H_{i,j}(S)$ is the total number of hours worked by all types of workers in industry i in country S.

We then use the relative quality levels of capital and labour inputs to estimate relative raw TFP levels (commonly referred to as relative Solow residuals). The relationship between the relative raw TFP levels and our estimates of relative TFP levels is given below:

$$\text{(A-5)}\quad \overline{\varphi}_i^D = \overline{v}_i^D + \overline{v}_i^K \ln\left[\frac{q_i^K(Can)}{q_i^K(US)}\right] + \overline{v}_i^L \ln\left[\frac{q_i^L(Can)}{q_i^L(US)}\right],$$

where $\overline{\varphi}_i^D$ is the raw TFP, $\overline{v}_i^D$ is the TFP, and $\overline{v}_i^K$ and $\overline{v}_i^L$ are the average capital and labour compensation shares of the two countries in industry *i*, as discussed in Section 5.3.

In Table 5.A1, we report relative quality levels of capital and labour inputs and assess their implications for relative TFP levels. Generally speaking, there are some variations in the relative levels of capital quality across industries between Canada and the United States. On the other hand, labour quality in Canada is slightly lower than in the United States in virtually all industries. In most cases, the effect of capital quality is offset by labour quality, resulting in a slight difference between relative raw TFP levels and the estimated TFP levels that incorporate capital and labour input quality differences.

Table 5.A1

Relative Capital and Labour Quality Levels and TFP Levels, 1995 (U.S. = 1.00)

Industry	Capital Quality	Labour Quality	TFP	Raw TFP
1. Agric., For. and Fisheries	1.57	0.99	0.83	0.89
2. Metal Mining	0.92	0.96	0.90	0.86
3. Coal Mining	0.83	0.98	1.16	1.09
4. Crude Pet. and Gas	0.91	0.92	0.71	0.66
5. Non-met. Mining	0.93	1.00	0.96	0.94
6. Construction	1.02	0.97	1.18	1.16
7. Food	1.00	0.95	0.96	0.95
8. Tobacco	0.95	1.01	2.06	2.02
9. Textile	0.98	1.01	0.98	0.98
10. Apparel	1.00	0.97	0.99	0.98
11. Lumber and Wood	1.06	0.97	1.01	1.01
12. Furniture	0.99	0.98	0.96	0.96
13. Paper	1.11	1.00	0.83	0.84
14. Printing	0.93	0.96	0.88	0.86
15. Chemicals	1.01	0.96	0.93	0.92
16. Petroleum Refining	0.74	0.99	1.15	1.12
17. Rubber and Plastics	1.12	0.97	0.85	0.86
18. Leather	1.11	0.95	0.83	0.83
19. Stone, Clay and Glass	1.07	0.98	0.87	0.88
20. Primary Metals	1.20	0.97	0.96	0.97
21. Fabricated Metals	1.05	0.98	0.84	0.84
22. Industrial Machinery	1.04	0.96	0.88	0.87
23. Electrical Machinery	0.87	0.98	0.98	0.96
24. Motor Vehicles	1.67	0.94	1.07	1.09
25. Other Trans. Equip.	0.88	0.95	0.98	0.95
26. Misc. Manufacturing	0.93	0.91	0.92	0.88
27. Trans. and Warehousing	0.81	0.97	0.87	0.84
28. Communications	1.00	0.97	0.99	0.98
29. Electric Utilities	0.98	0.98	1.24	1.22
30. Gas Utilities	0.97	0.96	1.15	1.13
31. Trade	0.83	0.95	1.02	0.97
32. Finance, Ins. and Real Estate	0.96	0.84	1.09	1.02
33. Other Services	1.00	0.94	0.93	0.90
Private Business Sector	1.02	0.97	0.88	0.86