# Productivity Levels Between Canadian and U.S. Industries

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## Abstract

This study, using the methodology given in Jorgenson and Kuroda (1995) and Lee and Tang (2001) and the new 1999 benchmark data on expenditure-based bilateral commodity purchasing power parities (PPPs) jointly developed by Statistics Canada and the U.S. Bureau of Labor Statistics, estimates Canada-U.S. bilateral PPPs for gross output, intermediate input, two types of capital stock [structures and machinery and equipment (M&E)] and value added in 31 industries. These PPPs in turn are used to estimate the Canada-U.S. labour productivity and multifactor productivity (MFP) level gaps for all these industries. These benchmark gaps in conjunction with the industry productivity growth rates in the two countries are then used to develop time series data on the labour productivity level gaps. The new estimates show that Canada's aggregate labour productivity was more than 20 percent below the U.S. level in 2003 and widened significantly since 1995. In addition, they show that Canada is more productive than the United States in most of the resource-based manufacturing industries, but less productive in the two machinery industries and in all service industries. The new results in general are consistent with the existing literature on the subject, but there are two key differences. First, the Canada-U.S. manufacturing labour productivity gap in this study is significantly lower than previous estimates. This difference is mainly due to the significant downward revisions to the productivity gaps in the two machinery industries. Second, this paper shows that the differences in capital intensity levels explain about 30 percent of the aggregate labour productivity gap between the two countries in 2001, and more than 50 percent of the Canada-U.S. manufacturing labour productivity gap. These estimates are significantly higher than those in Rao, Tang and Wang (2003).

## 1. Introduction

Canadians enjoy one of the highest standards of living and quality of life in the world. Moreover, both productivity and real per-capita income in Canada have increased at a significantly faster pace in the second half of the 1990s and in the 2000s. But, GDP per-capita in Canada, measured in purchasing power parity (PPP) exchange rate, was still on average 15 percent below the level in the United States (U.S.) in the past decade. About 85 percent of the income gap was attributed to the Canada-U.S. productivity gap, and the gap was generally pervasive across industries and provinces (Rao and Tang, 2004b).

A reliable estimate for the Canada-U.S. productivity gap is crucial for two important reasons. First, Canada's ability to compete effectively in international markets fundamentally depends on Canada's productivity relative to its trading partners, especially the U.S., its largest trading partner. Second, Canada's strength in attracting and retaining physical and human capital and innovation activities, fundamental drivers of economic growth, largely depends on Canada's ability to pay highly competitive returns to all the factors of production, which is fundamentally determined by its relative productivity. Hence, large and widening productivity gaps would erode Canada's future economic performance, creating a vicious cycle of low economic growth and a widening of productivity and real income gaps.

But, estimating real income and productivity level gaps in various industries across countries is tedious and time consuming, and requires large amounts of high quality data on prices, output and inputs. To compare productivity levels in different industries between Canada and the United States, accurate data on bilateral PPP exchange rates by industry is necessary, because use of the market exchange rate will lead to unreliable and misleading estimates for productivity gaps. Lee and Tang (2001), using the 1993 benchmark data on expenditure-based Canada-U.S. bilateral commodity PPPs, developed estimates for gross output based labour productivity and multifactor productivity (MFP) gaps for about 30 industries. Rao, Tang and Wang (2003), using the 1987 value-added based bilateral PPPs from Pilat (1996), estimated the labour productivity level gaps for Canadian industries.

There have been a number of significant developments since these previous studies of PPPs. First, software purchases are now treated as investments, as final demand rather than as intermediate inputs in the previous national account system. The new treatment significantly increases output and capital stock in terms of both levels and growth rates. Second, composition of industry output has changed significantly since 1993, especially during the economic resurgence in the second half of the 1990s. Information and communication technologies (ICTs) have been playing an increasingly important role in both ICT-producing and -using industries in the two countries.[1] Finally, there is a new benchmark survey on expenditure-based bilateral commodity PPPs between Canada and the United States, jointly developed by Statistics Canada

[1] A variety of studies find that the productivity growth revival in the second half of 1990s in the U.S. is due to production and use of ICTs (Jorgenson, Ho and Stiroh, 2002; Pilat and Lee, 2001). Some studies also show that the productivity growth pick-up in the second half of 1990s in Canada is mainly due to the use of ICTs (e.g. Rao and Tang, 2001).

and the U.S. Bureau of Labor Statistics. This paper will address these developments and in particularly, it will single out both ICT production and use.

The objective of this study is to develop new estimates for the Canada-U.S. productivity gaps for 31 industries, taking into account these new developments. Using the methodology in Jorgenson and Kuroda (1995) and Lee and Tang (2001) and the 1999 benchmark data on expenditure-based bilateral commodity PPPs between Canada and the United States, we calculate bilateral PPPs for gross output, intermediate input, two types of capital [(structures and machinery and equipment (M&E)] and value added for 31 industries. These in turn are used to develop estimates for value-added based labour productivity and MFP gaps in all the industries.

A gross output PPP is defined as the amount of Canadian dollars received by a Canadian producer from selling the same quantity of goods and services that a U.S. producer sells for one U.S. dollar. Similarly, an input PPP is defined as the amount of Canadian dollars required for a Canadian producer to purchase the same quantity of input that a U.S. producer purchases for one U.S. dollar.

We use Canada-U.S. bilateral commodity PPPs and convert them into industry PPPs by using gross output, input and investment structures of each industry that are estimated from input-output tables of the two countries. We group the business sector into 31 industries. The industries are not exact NAICS (North American Industry Classification System) industries. Instead, they are grouped in such a way so that we can establish a concordance between NAICS and SIC (Standard Industrial Classification).[2] The industry list and the corresponding NAICS codes are reported in Table 1. They are roughly at the 2-digit level for primary industries, the 3-digit level for manufacturing industries and the 2-digit level for services industries. Note, however, that computer and communication equipments are separated from electronic equipments due to the increasing importance of the two ICT industries.

The findings of this study in general are consistent with the conclusions of earlier studies (Rao, Tang and Wang, 2003; Lafortune and Lee, 2003). However, two findings of the current study differ from previous studies in two important aspects. First, the manufacturing labour productivity gap in this study is significantly lower than those in the earlier studies. For instance, the estimated gap in 1999 in this study was 18 percent, compared to 31 percent in Rao, Tang and Wang (2003). Nevertheless, both studies show a considerable widening of the gap since 1995. The productivity gaps in the two machinery industries in this paper are considerably lower than those in the previous study, largely due to differences in the PPPs. Second, this study suggests that differences in capital intensity in the two countries can explain about 30 percent of the aggregate Canada-U.S. labour productivity gap in 2001. In the manufacturing sector, more than 50 percent of the gap can be attributed to the capital intensity gap. These are significantly larger than those in Rao, Tang and Wang (2003).

Our paper is organized in the following way. Section 2 outlines the conceptual framework for developing bilateral PPPs between Canada and the United States, and discusses the new bilateral PPP estimates. Section 3 provides new estimates for labour productivity and MFP level gaps. It also provides estimates for Canada's price competitive position in all the industries. The last

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[2] The U.S. industry data for productivity analysis in this paper is based on SIC.

section, section 4, summarizes the key findings of the study and explores their implication for future research and public policy.

## 2. Estimating Bilateral Purchasing Power Parities for Output and Inputs

In this section, we explain how to adjust expenditure-based commodity PPPs for margins, which is required for estimating gross output PPPs at producers' prices. We then present the methods for converting commodity PPPs into industry PPPs, followed by a brief description of data required for constructing industry PPPs. Finally, we discuss the PPP estimates.

### 2.1. PPPs at Producers' Prices

The available raw PPPs, which are the essential data for this study, are expenditure-based bilateral commodity PPPs between Canada and the United States, evaluated at purchasers' prices. To estimate industry PPPs for gross output, we need to have production-based commodity PPPs at producers' prices. To obtain production-based commodity PPPs at producers' prices, the expenditure-based commodity PPPs must be adjusted for margins (which include indirect net commodity taxes and distribution margins).[3]

The purchasers' price of a commodity is equal to its producers' price plus all the related margins. Assuming that the margin value of purchasing a unit of the commodity can be expressed as a percentage share of its producers' price, we have:

**(1)** $$P_{j,s}^{E} = \overline{P}_{j,s}^{P}(1+\delta_{j,s}),$$

where $P_{j,s}^{E}$ and $\overline{P}_{j,s}^{P}$ are expenditure prices of commodity $j$ in country $s$ (expressed as the national currency of country $s$) at purchasers' and producers' prices, respectively, and $\delta_{j,s}$ is the margin rate of commodity $j$ in country $s$.

The Canada-U.S. expenditure-based bilateral commodity PPP of a commodity is the ratio of national prices of the commodity in the two countries, i.e.,

**(2)** $$\overline{PPP}_{j}^{P} = \frac{\overline{P}_{j,CA}^{P}}{\overline{P}_{j,US}^{P}} = \frac{P_{j,CA}^{E}\big/(1+\delta_{j,CA})}{P_{j,US}^{E}\big/(1+\delta_{j,US})} = \frac{1+\delta_{j,US}}{1+\delta_{j,CA}} PPP_{j}^{E} \text{ ,}$$

[3] Ideally, they should also be adjusted for international trade (exports and imports), as the one suggested by Hooper and Vrankovich (1995). Exports are domestically produced but not domestically consumed, while imports are domestically consumed but not domestically produced. An adjustment for exports and imports is desirable to convert expenditure-based PPPs to production-based PPPs. However, due to data limitation, this paper, like all previous studies, will not make the adjustment.

where $PPP_j^E$ and $\overline{PPP}_j^P$ are Canada-U.S. expenditure-based bilateral commodity PPPs for commodity $j$ at purchasers' and producers' prices, respectively.

The margin rates for each commodity can be estimated from the input-output accounts of the two countries.

## 2.2. Industry PPPs

Industry PPPs can be derived from production-based and expenditure-based commodity PPPs and input-output structures of the two countries. This study follows the methodologies used in Jorgenson and Kuroda (1995) and Lee and Tang (2001).

### *2.2.1. PPPs for Gross Output*

In this subsection we describe the method for converting commodity PPPs at producers' prices to gross output PPPs at the industry level. An industry gross output is defined as the value of the industry's production at producers' prices. For most industries, it is the sum of all commodities produced at producers' prices. However, for margin industries such as transportation, retail and wholesale trade industries, gross outputs are mainly margins received, not the value of goods transported or traded. Thus, gross output PPPs for these industries cannot be derived from expenditure-based commodity PPPs. In this study, gross output PPPs for these industries are assumed to be 1.18, the same as the Statistics Canada 1999 GDP PPP.

In the remainder of this subsection, we construct gross output PPPs for all industries except transportation, retail and wholesale trade. As defined previously, the Canada-U.S. bilateral gross output PPPs are the amount of Canadian dollars received by Canadian producers from selling the same quantity of the output that a U.S. producer sells for one U.S. dollar. For industry $i$, the gross output PPP is estimated by aggregating the industry's expenditure-based commodities PPPs at producers' prices over all the commodities produced by industry $i$ in a trans-log form, using nominal shares in the commodity mix as weights for the industry. That is,

$$\textbf{(3)} \qquad \ln\left(PPP_i^Y\right) = \sum_j \frac{1}{2}\left(w_{i,j,CA}^Y + w_{i,j,US}^Y\right)\ln\left(\overline{PPP}_j^P\right), \quad \text{with} \quad w_{i,j,s}^Y = Y_{i,j,s} \Big/ \sum_j Y_{i,j,s},$$

where $Y_{i,j,s}$ is the nominal gross output of commodity $j$ at producers' price in industry $i$ in country $s$, obtained from the *make* matrices of the input-output tables, and $w_{i,j,s}^Y$ is the nominal share of commodity $j$ in industry $i$ in country $s$.

### *2.2.2. PPPs for Intermediate Input*

Unlike industry gross output PPPs, industry PPPs for intermediate inputs should be calculated from the purchasers' standpoint, which implies that they need to be converted from expenditure-based commodity PPPs at purchasers' price. That is,

(4) $$\ln\left(PPP_i^{\Phi}\right) = \sum_j \frac{1}{2}\left(w_{i,j,CA}^{\Phi} + w_{i,j,US}^{\Phi}\right)\ln\left(PPP_j^{E}\right), \text{ with } w_{i,j,s}^{\Phi} = \Phi_{i,j,s} \Big/ \sum_j \Phi_{i,j,s} ,$$

where $\Phi_{i,j,s}$ is the value of commodity $j$ as an intermediate input in industry $i$ in country $s$, obtained from the *use* matrices of the input-output tables, and $w_{i,j,s}^{\Phi}$ is the share of commodity $j$ in total value of intermediate inputs used by industry $i$ in country $s$.

*2.2.3. PPPs for Investment*

Industry PPPs for new investment should also be calculated from the purchasers' standpoint. These PPPs are defined as the amount of Canadian dollars required for a Canadian producer to purchase the same quantity of new investment goods that a U.S. producer purchases for one U.S. dollar. We group new investment goods into M&E and structures. The PPP for new investment type $I$ (M&E, structures, or both (total investments)) in industry $i$ is aggregated over commodities in a trans-log form, i.e.,

(5) $$\ln\left(PPP_i^{I}\right) = \sum_j \frac{1}{2}\left(w_{i,j,CA}^{I} + w_{i,j,US}^{I}\right)\ln\left(PPP_j^{E}\right), \text{ with } w_{i,j,s}^{I} = K_{i,j,s}^{I} \Big/ \sum_j K_{i,j,s}^{I} ,$$

where $K_{i,j,s}^{I}$ is the value of commodity $j$ as investment type $I$ in industry $i$ in country $s$, obtained from the *final demand* matrix for Canada and the capital flow matrix for the United States, and $w_{i,j,s}^{I}$ is the share of commodity $j$ in total value of investment type $I$ purchased by industry $i$ in country $s$.

*2.2.4. PPPs for Value Added*

PPPs for value added are derived from its relationship with gross output and intermediate input. Value added is calculated as a residual of gross output minus intermediate input. Following Jorgenson (1995), a trans-log form of Canada-U.S. relative value added can be defined as

(6) $$\ln\left(V_{i,CA}/V_{i,US}\right) = \frac{1}{\bar{v}_i}\ln\left(Y_{i,CA}/Y_{i,US}\right) - \frac{1-\bar{v}_i}{\bar{v}_i}\ln\left(\Phi_{i,CA}/\Phi_{i,US}\right),$$

where $V_{i,s}$ is value added for industry $i$ in country $s$; $Y_{i,s}$ is gross output value for industry $i$ in country $s$; $\Phi_{i,s}$ is value of intermediate inputs for industry $i$ in country $s$; and $\bar{v}_i$ is the average share of nominal value added in gross output of the two countries for industry $i$, i.e.,

(7) $$\bar{v}_i = \frac{1}{2}\left(\frac{V_{i,CA}}{Y_{i,CA}} + \frac{V_{i,US}}{Y_{i,US}}\right) .$$

Note that equation (6) is valid in national currencies or PPP adjusted values, so the industry PPPs for value added can be expressed as

$$\textbf{(8)} \qquad \ln PPP_i^{v} = \frac{1}{\bar{v}_i} \ln PPP_i^{Y} - \frac{1-\bar{v}_i}{\bar{v}_i} \ln PPP_i^{\Phi}.$$

Thus, the derived PPPs from equation (8) is the implicit PPPs for value added for industry *i*.

### 2.3. Data for the Estimation of PPPs

To implement the methodology described above, we require data on PPPs for commodities between Canada and the United States, and the input-output tables with different margins for both Canada and the United States.

The basic data on commodity PPPs are Canada-U.S. expenditure-based bilateral PPPs for 221 basic headings in 1999 and they are aggregated over more than 2,000 commodities.[4] They are developed jointly by Statistics Canada and the U.S. Bureau of Labor Statistics. However, the commodity PPPs are mainly for commodities that are produced for final consumptions. The dataset does not have PPPs for most commodities that are primarily used as intermediate inputs. To fill the gap, we first use 1999 Canada-U.S. market exchange rate as a proxy PPP for commodities (such as grains, wheat, copper, steel, and precious metals) that are heavily traded in the North American or the world markets. Other commodities that are used as intermediate inputs in the manufacturing sector, such as chemical, rubber and plastic, non metallic minerals, and metal products, are proxied by unit value ratios (UVRs)[5] for 1997 from van Ark, Inklaar and Timmer (2000), and updated to 1999, using information from the KLEMS database for both Canada and the United States (Ho, Rao and Tang, 2004).

The second major data required for the exercise are input and output tables expressed in current dollar for both Canada and the United States. For Canada, we obtained the make and use tables at the public aggregate level (713 commodities by 283 NAICS-based industries) and the final demand table at the public aggregate level (713 commodities by 170 expenditures) for 1999 from Statistics Canada. The final demand table contains information on capital expenditures by asset types for detailed industries. These tables are mainly used to measure the commodity composition for each industry. For Canada, we also obtained input and final demand margins for 1999 (transportation, wholesale, retail and net indirect commodity tax) of 713 commodities from Statistics Canada. They are used to derive commodity PPPs at producers' prices by "peeling off" the margins from expenditure commodity PPPs.

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[4] Commodity PPPs are updated every three years. The 1999 data were the most current at the time of this study. Statistics Canada performed the detailed level calculations and aggregation of these PPPs.

[5] UVR and PPP are alternatives used in the literature to convert different currencies into a common currency in international productivity comparison. The major difference between the two approaches is that the former is based on product unit values derived from value and quantity information for product group and the latter is based on final expenditure information. For the discussion of the strengths and weaknesses of the two approaches, see van Ark, Inklaar and Timmer (2000).

Similarly, we obtained the corresponding 1999 input and output tables for the United States from the U.S. Bureau of Economic Analysis. However, the U.S. make and use tables (margins included) are at a very aggregated level (97 commodities by 97 SIC-based industries). So we supplemented the 1999 tables with information from the 1997 make and use tables (margins included) that are at the detailed level (511 commodities by 511 NAICS-based industries). In other words, we used the commodity composition structure from the 1997 tables, controlling the totals from the 1999 tables. In addition, we obtained the 1997 capital flow table (180 commodities by 123 NAICS-based industries) for the United States, which was used to measure the commodity composition of investment in each industry.

The data associated with the input and output tables for Canada and the United States have different commodity codes and they are at a different industry level. In addition, the commodities with PPPs are more aggregated than those in the input and output tables. As a final step in the data preparation, we establish a common commodity level with 227 commodity headings for both Canada and the United States. Both the Canadian and U.S. tables are converted into new tables with the 227 commodities and the 31 industries (Table 1). These new tables are then used to calculate the margin rates and industry shares for each heading in both countries. The margin rates will be used to convert expenditure-based commodity PPPs at purchasers' price to production-based commodity PPPs at producers' price, and the industry shares of each commodity, measuring the commodity composition structure for each industry, will be used to estimate industry PPPs.

### 2.4. Discussion of the PPP Estimates

In this section, we briefly discuss the industry PPP estimates and compare them to official estimates at the aggregate level.

#### 2.4.1. PPPs for Gross Output, Intermediate Input and Value Added

PPP estimates for gross output, intermediate inputs and value added are reported in Table 2. Gross output PPPs vary significantly across industries. Industries with their outputs heavily traded in the North American or the world market have high gross output PPPs and are close to the market exchange rate. These industries are agriculture, textile and clothing, wood, rubber and plastic, fabricated metal, machinery, computer, communication equipment, electrical equipment, and furniture. On the other hand, for industries that are not heavily traded internationally such as services and construction, the gross output PPPs are well below the market exchange rate, and are closer to the parity.

PPPs for intermediate inputs are less variable across industries than gross output PPPs.[6] There is no industry that has intermediate input PPP higher than the market exchange rate. Like gross output PPPs, the intermediate PPPs for service industries are on the low side, and those for most manufacturing industries are on the high side.

[6] This partly reflects the fact that we used the proxy data (the market exchange rate) for some commodity PPPs used for intermediate inputs.

The PPP for value added in the business sector is 1.14, which is similar to the official estimates for the total economy (1.18). The small difference is partly because the value added in this paper is at producers' price while the official estimate is at purchasers' price. It may also reflect the difference in coverage (this study does not cover the non-business sector). At the industry level, value added PPPs are much more variable across industries than both gross output and intermediate input PPPs. This may be partly due to the fact that they are estimated implicitly. The value added PPPs are higher than the market exchange rate in 13 industries while they are below one in three industries.

2.4.2. PPP for Investment

PPP estimates for total new investment as well as investments in M&E and structures are reported in Table 3. Our estimate of PPP for total investment for the business sector in 1999 is 1.20, which is similar to the official Statistics Canada estimate for gross fixed capital formation (1.17). Again, the slight difference between the two estimates may reflect the difference in coverage.

The PPP for M&E investment for the business sector is 1.37 in 1999, which includes expenditures on not only M&E but also software products. The official Statistics Canada estimate is 1.47 for M&E excluding software, which more or less is equal to the market exchange rate, and 0.79 for software products. The PPP for investment in structures for the business sector is 1.03 in 1999, compared to 1.02 of the official estimate by Statistics Canada. It is identical for all industries but one, because there is only one type of investment in structures (construction) in all these industries.

The PPP estimates for investment in M&E being significantly higher than those for investment in structures reflect the fact that much of the M&E is imported.

## 3. Productivity Levels and Price Competitiveness of Canadian and U.S. Industries

This section fulfils the second objective of this study, that is, to compare productivity levels and international price competitiveness of Canadian and U.S. industries, based on the PPPs estimates above. To carry out such comparisons, we first set up the framework.

### 3.1. The Framework for Productivity Level Comparisons

As in Jorgenson and Nishimizu (1978), our theoretical framework for productivity and international price competitiveness comparisons between Canada and the United States is based on a trans-log production function, originally introduced by Christensen, Jorgenson and Lau (1971, 1973). Here, output (value added)[7] is a trans-log function of capital and labour, 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.

[7] For the analysis at the industry level, Jorgenson and his associates often rely on the gross output concept for productivity analysis, that is, inputs also include intermediate inputs. Unfortunately, we do not have the data for conducting a similar analysis.

From the production function, Jorgenson, Kuroda and Nishimizu (1995) and Christensen, Cummings and Jorgenson (1995) show that differences in the logarithms of the multi-factor productivity (MFP) levels between Canada and the United States, for the *i*th industry, can be expressed as the value of the difference between the logarithms of the value added, less a weighted average of the differences between the logarithms of inputs:

**(9)** $$\ln\left[\frac{MFP_i(Can)}{MFP_i(US)}\right] = \ln\left[\frac{LP_i(Can)}{LP_i(US)}\right] - \hat{v}^K \ln\left[\frac{k_i(Can)}{k_i(US)}\right],$$

where $MFP_i(S)$ is the MFP level for the *i*th industry in country S; $LP_i(S)$ is the PPP-based labour productivity level, defined as value added per hour worked, for the *i*th industry in country *S*; $k_i(S)$ is the PPP-based capital intensity level, defined as capital stock per hour worked, for the *i*th industry in country *S*; and $\hat{v}_i^K = \frac{1}{2}\left[v_i^K(Can) + v_i^K(US)\right]$, the average compensation share of capital in Canada and the United States for the *i*th industry.

Thus, the relative MFP between Canada and the United States is equal to the relative labour productivity net of the relative contributions attributed to the capital intensity. Note, however, that the MFP measure is significantly different from Lee and Tang (2001). Following the Jorgensonian framework closely, they also control for the quality of capital and labour inputs. In other words, they recognize that the marginal products of different capital and labour are different. So they treat M&E and structures, and university education and non-university education differently by assigning different weights to them.[8] In short, their MFP measure is net of quality improvements in capital and labour. In contrast, the MFP estimate in the current study includes the quality improvements.

### 3.2. The Framework for Price Competitiveness Comparisons

Following Jorgenson and Kuroda (1995), we measure price competitiveness by relative value added prices, defined as value added PPPs divided by the market exchange rate ($CDN per $US). According to Lee and Tang (2001), the value added price for a Canadian industry relative to its U.S. counterpart is positively related to the relative input costs and negatively related to the relative MFP. A relative input cost is defined as the PPP of the input divided by the market exchange rate. The relative MFP is the ratio of MFP in Canada to that in the United States. If the relative value added price for the *i*th industry is below one, then the industry is said to be more competitive in Canada than in the United States, and vice versa.

### 3.3. Data for Productivity and Price Competitiveness Comparisons

To implement the above framework, we require data on output, capital and labour by industry. In addition, we need data on factor compensation. For Canada, the nominal GDP at the basic price is from CANSIM table 379-0023, which is converted to factor cost by "peeling off" the net

[8] The weights are factor compensation, which essentially assumes that the marginal product of a unit of factor is equal to the factor compensation for the unit.

indirect taxes on production. Total hours worked is from CANSIM table 383-0010. Non-residential capital stock, geometric (infinite) end-year net stock is extracted from CANSIM table 031-0002. And, finally, the factor compensation data are derived from the input and output tables. All Canadian data are NAICS-based and converted into the 31 industries in Table 1.

For the United States, GDP at factor cost and factor compensation data are from the U.S. Bureau of Economic Analysis (GPO87SIC.xls). Data on total hours worked for 1999-2000 from Ho, Rao and Tang (2004), is extended to 2001 using growth rate of full-time equivalent employment from the U.S. Bureau of Economic Analysis (GPO87SIC.xls). Data on non-residential capital stock are also from the U.S. Bureau of Economic Analysis. All U.S. data are SIC-based and converted into the 31 industries in Table 1.

### 3.4. Productivity Levels in Canada Relative to Those in the United States

In this section, we discuss the results on productivity level comparisons between Canadian and U.S. industries. We first deal with labour productivity level comparisons.

3.4.1. Labour Productivity Levels in Canada Relative to Those in the United States

We first calculate labour productivity levels in Canada relative to those in the United States for 26[9] industries in 1999. The results are presented in Table 4, and they are generally consistent with the findings in our earlier study (Rao, Tang, and Wang, 2003), with a few exceptions.

In 1999, Canada's labour productivity level in the business sector was 82 percent of the U.S. level, an 18 percent gap between the two countries. The gap is similar to the previous estimate of 16 percent for the total economy in 1999 (Table 5). However, the new estimate of the labour productivity gap of 18 percent in the manufacturing sector is considerably smaller than the gap of 31 percent in Rao, Tang and Wang (2003). There are at least three main possible reasons for the discrepancy between the two estimates. [10] First, there is no reliable value added PPP for the total manufacturing sector in the earlier study. Using the labour productivity growth rates in the manufacturing sector in Canada and the United States, the earlier study derived the labour productivity level gap for 1999 by extrapolating the benchmark value for 1987 (de Jong, 1996). The benchmark estimate was calculated on the basis of the unit value ratios (UVRs) approach developed by the International Comparison of Output and Productivity (ICOP) project at the

[9] Due to data limitations, computer and machinery are combined into one industry, and communication equipment, other electronic product and electrical product are combined into another industry. We also drop miscellaneous manufacturing (23) and other services (31) due to data quality concerns.

[10] There are other two possible reasons for causing the discrepancy. Labour productivity in this paper is defined as value added per hour worked, while it is defined as value added per worker in the earlier study. As we know, on average, Americans work more hours than Canadians. For instance, the average hours worked per employee in 1999 for the total manufacturing sector was 1,982 hours in Canada (Source: Statistics Canada) and 2,055 hours in the United States (Sources: Ho, Rao and Tang, 2004 and the U.S. Bureau of Economic Analysis). As a result, the Canada-U.S. labour productivity level gap based on value added per hour worked is smaller. In addition, the base year in the current paper is 1999 while our earlier estimate is based on 1990. This may be another reason for the difference since the relative labour productivity level is sensitive to the base year. Note that the output in the manufacturing sector is aggregated over many different commodities/industries, which is influenced by both quantities and prices of the commodities/industries in the manufacturing sector (Tang and Wang, 2004).

University of Groningen (van Ark, Inklaar and Timmer, 2000). The simple extension of the relative level in 1987 to 1999 may not truly reflect the changes in the commodity composition over this period. Second, both the U.S. Bureau of Labor Statistics and Statistics Canada recently made major revisions to labour productivity data for the manufacturing sector. Finally, PPPs derived from the expenditure-based commodity PPPs, used in the current study, can be significantly different from unit value ratios (UVRs) used by de Jong (1996), hence a significant difference in the estimate of the labour productivity gap between the two countries. We believe that the estimates in the current paper are more up-to-date and more reliable.

In 1999, Canada was less productive than the United States in 17 of the 26 industries, including all the industries associated with the information and communication technologies industries (machinery and computers, electronic and electrical equipment, and information and cultural industries), as shown in Table 4. The productivity gap is significantly larger in petroleum and coal products, fabricated metals, textile and clothing, and FIRE (finance, insurance, real estate and rental and leasing). On the other hand, Canada is more productive in nine industries. Many of these are resource-based industries. The productivity advantage is greater in construction, primary metals, paper, and non-metallic minerals.

In machinery and computer, and electronic and electrical equipment, Canada's labour productivity levels were 63 and 70 percent of the U.S. levels, respectively. The estimates are significantly larger than the earlier estimates of only about 30 percent (Table 5). We believe the major difference between the two studies is due to the fact that the value-added PPPs for the two industries in the current study are significantly lower than the PPPs used in Rao, Tang and Wang (2003). The change in the benchmark year as well as the revisions to labour productivity data in the two countries might have also contributed to the difference.

We extended the level estimates in 1999 backward to 1997 and forward to 2001 using the labour productivity growth rates in Canada and the United States for 1997-2001.[11] Both the level and growth estimates are reported in Table 6. Basically, the table shows that in the last five years, Canada has improved its labour productivity relative to the United States in primary industries and construction, but lagged the United States in the manufacturing sector. Canada's poor performance in the manufacturing sector is mainly due to the two industries associated with computers and electronics. The machinery and computer industry in Canada saw its productivity level relative to the United States fall from 85 percent in 1997 to 63 in 2001. Similarly, for electronic and electrical equipment, the relative productivity level fell from 66 to 44 percent. In addition, we extended the estimates in 1999 to 1987-2003 for the aggregate manufacturing sector and the business sector (Figure 1). Clearly, the Canada-U.S. labour productivity gap widened dramatically since the middle of the 1990s, especially in the manufacturing sector. In 2003, Canada's labour productivity level in the manufacturing sector was 69 percent of the U.S. level, compared to 88 percent in 1995. Similarly, during this period, in the business sector, the productivity gap increased by 8 percentage points.

3.4.2. MFP Levels in Canada Relative to those in the United States.

[11] Real GDP data are based on CANSIM table 379-0017 for Canada and the U.S. Bureau of Economic Analysis (GPO87SIC.xls) for the U.S. We cover only the period of 1997-2001 because the data for Canada only starts at 1997 (due to the adoption of the NAICS) and the data for U.S. are only available up to 2001.

Based on equation (9), we calculated relative MFP levels in 1999 in Canada and the United States for the 26 industries. The estimated relative MFP levels by industry are also reported in Table 4.

In 1999, Canada was less productive than the United States in the business sector, and the gap was 14 percent. At the industry level, Canada was less productive than the United States in 18 of the 26 industries. In particular, Canada was much less productive in petroleum and coal products, utility, and fabricated metal. On the other hand, in 1999, Canada was significantly more productive than the United States in other transportation equipment, primary metal, printing, non-metallic, and construction.

On average, Canada is doing much better in MFP than in labour productivity vis-à-vis the United States. The MFP gap in 1999 was lower than the labour productivity gap in the two major sectors: manufacturing and services. The difference in the two gaps was particularly significant in the manufacturing sector (18 percent for the labour productivity gap compared to 10 percent for the MFP gap).

In 17 of the 26 industries, the MFP gap was lower than the labour productivity gap. The difference in the two gaps is mainly attributable to the lower capital intensity[12], especially the M&E capital intensity (Table 4).[13] The correlation between the relative labour productivity level and the relative capital intensity level was 0.55 in 1999, which is highly significant. The capital intensity gap between the two countries explains about 25 percent of the labour productivity gap in the business sector and more than 50 percent of the manufacturing sector labour productivity gap.[14] These are significantly higher than the findings for 2000 in Rao, Tang and Wang (2003).

As shown in Rao, Tang and Wang (2003), the M&E capital intensity is lower in Canada than that in the United States because of a relatively higher cost of M&E investment in Canada due to the heavy reliance on imported capital and the weak Canadian dollar. In 1999, the M&E capital intensity in Canada was only 55 percent of the U.S. level, compared to 89 percent for the total capital intensity.

### 3.5. Price Competitiveness between Canadian and U.S. Industries

This section assesses differences in price competitiveness between Canadian and U.S. manufacturing industries and relates them to their MFP levels. The relative prices for value added, capital and labour, and relative MFP levels for 1999 are reported in Table 7. In 18 of the 26 industries, Canadian industries had a lower relative price for value added and hence were more price competitive than their U.S. counterparts. Recall that relative value-added price is positively related to relative input prices and negatively related to relative MFP level.

[12] Canada's capital intensity is based on capital stock estimates from the Investment and Capital Stock Division of Statistics Canada. The capital stocks are estimated using the same declining-balance rates as those in the U.S.
[13] As shown in Rao, Tang and Wang (2003), M&E capital is lower because of the relatively higher cost of M&E investment which relies on imports. In 1999, the capital intensity (PPP based) in Canada was only 55 percent of the U.S. level for M&E compared to 89 percent of the level for total capital.
[14] The contribution rates are calculated when the productivity gaps are in log difference.

With respect to capital, Canada had a lower or equal capital price for total investment in all industries.[15] The lower cost of total investment was mainly because Canada had a substantially lower cost in structures investment. On the other hand, Canada had a slightly higher M&E investment price in 11 industries, all in the manufacturing sector.

In Table 7, we also report the relative wage rate between Canadian and U.S. industries.[16] Unlike investment price, all Canadian manufacturing industries had a significant advantage over their U.S. counterparts in labour compensation, on average about 66 percent of the U.S. level. The variation in relative wage rate across industries was very small. As a result of the differences in input prices, the input structures are different in the two countries. Canadian industries are generally more labour-intensive, while their U.S. counterparts tend to be more capital-intensive. These findings are consistent with the conclusions of Rao, Tang and Wang (2003).

The correlation coefficient between relative value-added prices and relative MFP levels across all industries in 1999 is -0.42 while the correlation coefficients with capital and labour prices are 0.36 and 0.15, respectively. These correlations indicate that inter-industry variation in relative value-added prices across industries is more strongly influenced by inter-industry variation in relative MFP levels.

We summarize the relationship between value-added prices and MFP levels by plotting relative value-added prices against relative MFP levels for 1999 across industries, as shown in Figure 2. To better illustrate the relationship between price competitiveness and relative MFP levels, we divide the figure into four quadrants. Quandrants I and II show Canadian industries which are less price competitive than their U.S. counterparts, while quadrants III and IV show Canadian industries that are more price competitive than their U.S. equivalents. At the same time, Canadian industries in quadrants II and III are more productive than their U.S. counterparts, while relatively less productive industries in Canada are located in quadrants I and IV.

In 1999, eight Canadian industries were less price competitive and less productive than U.S. industries (quadrant I). They are agriculture, textile and clothing, wood products, plastic and rubber products, fabricated metal, machinery and computers, electronic and electrical equipments, and furniture and related products. As shown in Table 7, lower productivity is the reason for those industries being less price competitive. No industry was less price competitive but more productive than its U.S. counterpart (quadrant II). An examination of quadrant III reveals that 10 Canadian industries were more price competitive and more productive than U.S. industries. Nine of these industries had relatively lower input prices as well as higher MFP level than their U.S. counterparts (Table 7). The last quadrant IV shows eight industries where Canada was more price competitive but less productive than the United States (mining, paper, petroleum and coal products, chemicals, utility, retail trade, transportation, information and

[15] Note that investment prices are very different from the user cost of capital since the latter is also influenced by other factors including taxes (see Jorgenson and Yun, 2001).

[16] Relative wage rate is calculated as the ratio of wage rate in Canada in Canadian dollars to the wage rate in the U.S. in U.S. dollars, divided by the market exchange rate. In this paper, the wage rate in each country is simply calculated as total labour compensation divided by total hours worked. Thus, the relative wage rate is different from the relative price for labour input in Lee and Tang (2001) who control for quality of hours worked.

cultural industries, and finance, insurance and real estate). Canada's competitive position in these industries stemmed entirely from lower input prices.

## 4. Conclusions

The main objective of this study has been to develop new and up-to-date estimates for the Canada-U.S. labour productivity and MFP gaps at the industry level. Using the methodology in Jorgenson and Kuroda (1995) and Lee and Tang (2001) and the 1999 expenditure-based bilateral commodity PPPs, we calculated bilateral PPPs for gross output, intermediate input, two types of capital stocks and value added for 31 industries. These PPP estimates in turn were used to develop estimates for labour productivity and MFP gaps in all the industries. The benchmark gaps in conjunction with industry labour productivity growth rates in the two countries were used to develop a time series for the gaps during the period 1997-2001.

This paper shows that the aggregate Canada-U.S. labour productivity gap in 1999 was around 18 percent and the MFP gap was about 14 percent. In the manufacturing sector, the labour productivity gap was 18 percent and the MFP gap was about 10 percent. The labour productivity estimates in the manufacturing sector are significantly lower than the previous estimates (Rao, Tang and Wang, 2003). The difference in the aggregate manufacturing labour productivity gap between the current study and the earlier study can be mainly attributed to the differences in the estimates for PPPs for the two machinery industries. The new PPPs are significantly lower than the previous estimates. Consequently, the labour productivity gaps in these two industries in this study are considerably lower than the previous estimates. More importantly, this study shows that differences in capital intensity in the two countries explain about 30 percent of the aggregate Canada-U.S. labour productivity gap and more than 50 percent of the manufacturing sector labour productivity gap in 2001, which are significantly higher than those reported in Rao, Tang and Wang (2003).

This paper shows that in 17 of the 26 industries, Canadian industries had lower labour productivity and 18 had lower MFP levels compared to their U.S. counterparts in 1999. It also finds that in 1999, 18 of the 26 Canadian industries had a lower relative value-added price and thus were more price competitive than their U.S. counterparts. MFP level has been an important determinant of Canada's international price competitiveness. Nine of the Canadian industries with price competitiveness advantage relative to the United States in 1999 were entirely due to lower input prices in Canada, especially labour compensation. On average, the wage rate in Canada was only about 66 percent of the U.S. level.

These findings indicate the importance of improving Canada's relative productivity for improving Canada's price competitiveness, and also the business climate in Canada. Canada needs to maintain highly competitive market framework policies for retaining and attracting business investment and innovation activities to Canada. A recent OECD (2003) study shows that by bringing down its foreign direct investment (FDI) regulations to U.K. levels which are the lowest among the OECD countries, and reducing the product market regulations to the OECD average, Canada could double its FDI stock. Such an increase in FDI stock will increase capital intensity, expand trade, increase research and development (R&D) and ultimately improve productivity and living standards in Canada (Rao and Tang, 2004a). The recent appreciation of the Canadian dollar in late 2003 and early 2004 would reduce the price of capital relative to labour, especially for M&E capital, which in turn would stimulate investment and improve productivity in Canada.

Our study suggests that future research should do an in-depth analysis of the determinants of MFP and capital intensity in Canada and the United States. In particular, the role of taxes, investment incentives, labour compensation, availability of skilled labour, labour market and FDI regulations need to be explored. Canada-U.S. border risk in business investment decisions in Canadian and U.S. industries needs also to be studied.

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**Table 1: Industry Classification**

| Industries | NAICS Codes |
|---|---|
| **Primary Industries** | |
| 1 Agriculture (including forestry, fishing and hunting) | 11 |
| 2 Mining | 21 |
| **Construction** | |
| 3 Construction | 23 |
| **Manufacturing Industries** | |
| 4 Food, beverage and tobacco | 311-312 |
| 5 Textile and clothing | 313-316 |
| 6 Wood product | 321 |
| 7 Paper | 322 |
| 8 Printing and publishing* | 323, 511, 514 |
| 9 Petroleum and coal products | 324 |
| 10 Chemicals | 325 |
| 11 Plastic and rubber products | 326 |
| 12 Non-metallic mineral product | 327 |
| 13 Primary metal | 331 |
| 14 Fabricated metal | 332 |
| 15 Machinery | 333 |
| 16 Computer | 3341 |
| 17 Communications equipment | 3342 |
| 18 Other electronic equipments | 3343-3346 |
| 19 Electrical equipments | 335 |
| 20 Motor vehicle | 3361-3363 |
| 21 Other transportation equipment | 3364-3369 |
| 22 Furniture and related product | 337 |
| 23 Miscellaneous manufacturing | 339 |
| **Services Industries** | |
| 24 Utility | 22 |
| 25 Wholesale trade | 41 |
| 26 Retail trade | 44-45 |
| 27 Transportation | 48-49 |
| 28 Information and cultural industries** | 512, 513 |
| 29 FIRE (Finance, insurance, real estate and rental and leasing) | 52-53 |
| 30 Business services | 54-56 |
| 31 Other services | 61-81 |

* We do not have data to separate information services and data processing services industry (NAICS 514) from publishing industry (NAICS 511) for Canada.  So both industries are included in printing and publishing industry.

** It only includes Motion picture and sound recording industries (NAICS 512) and Broadcasting and telecommunications (NAICS 513)

**Table 2: Industry PPPs for Gross Output, Intermediate Input and Value Added, 1999**

| Industry | Gross Output | Intermediate input | Value added |
|---|---|---|---|
| **Primary Industries** | **1.43** | **1.34** | **1.56** |
| 1 Agriculture | 1.48 | 1.38 | 1.66 |
| 2 Mining | 1.36 | 1.30 | 1.46 |
| **Construction** | **1.03** | **1.17** | **0.87** |
| 3 Construction | 1.03 | 1.17 | 0.87 |
| **Manufacturing Industries** | **1.37** | **1.36** | **1.40** |
| 4 Food, beverage and tobacco | 1.34 | 1.33 | 1.37 |
| 5 Textile and clothing | 1.52 | 1.42 | 1.70 |
| 6 Wood product | 1.49 | 1.40 | 1.65 |
| 7 Paper | 1.26 | 1.33 | 1.14 |
| 8 Printing and publishing | 1.13 | 1.27 | 0.97 |
| 9 Petroleum and coal products | 1.34 | 1.44 | 1.25 |
| 10 Chemicals | 1.18 | 1.28 | 1.03 |
| 11 Plastic and rubber products | 1.44 | 1.26 | 1.72 |
| 12 Non-metallic mineral product | 1.18 | 1.30 | 1.05 |
| 13 Primary metal | 1.30 | 1.33 | 1.20 |
| 14 Fabricated metal | 1.67 | 1.37 | 2.07 |
| 15-16 Machinery and computer | 1.55 | 1.42 | 1.71 |
| 15 Machinery | 1.59 | 1.45 | 1.75 |
| 16 Computer | 1.44 | 1.31 | 1.59 |
| 17-19 Electronic and electrical equipment | 1.46 | 1.33 | 1.68 |
| 17 Communications equipment | 1.47 | 1.32 | 1.66 |
| 18 Other electronic equipment | 1.44 | 1.33 | 1.63 |
| 19 Electrical equipment | 1.49 | 1.33 | 1.79 |
| 20 Motor vehicle | 1.38 | 1.42 | 1.28 |
| 21 Other transportation equipment | 1.37 | 1.40 | 1.33 |
| 22 Furniture and related product | 1.46 | 1.34 | 1.59 |
| 23 Miscellaneous manufacturing | 1.33 | 1.30 | 1.36 |
| **Services Industries** | **1.17** | **1.27** | **1.09** |
| 24 Utility | 1.26 | 1.29 | 1.25 |
| 25 Wholesale trade | 1.18 | 1.24 | 1.15 |
| 26 Retail trade | 1.18 | 1.21 | 1.16 |
| 27 Transportation | 1.18 | 1.41 | 1.00 |
| 28 Information and cultural industries | 1.17 | 1.25 | 1.09 |
| 29 FIRE | 1.13 | 1.19 | 1.09 |
| 30 Business services | 1.20 | 1.24 | 1.18 |
| 31 Other services | 1.00 | 1.31 | 0.73 |
| **Business Sector** | **NA** | **NA** | **1.14** |

**Table 3: Industry PPPs for Total Investment, M&E and Structures, 1999**

| Industry | Total investment | M&E | Structures |
|---|---|---|---|
| **Primary Industries** | **1.23** | **1.38** | **1.03** |
| 1 Agriculture | 1.29 | 1.37 | 1.03 |
| 2 Mining | 1.22 | 1.39 | 1.03 |
| **Construction** | **1.34** | **1.37** | **1.03** |
| 3 Construction | 1.34 | 1.37 | 1.03 |
| **Manufacturing Industries** | **1.40** | **1.49** | **1.03** |
| 4 Food, beverage and tobacco | 1.40 | 1.50 | 1.03 |
| 5 Textile and clothing | 1.41 | 1.47 | 1.03 |
| 6 Wood product | 1.39 | 1.50 | 1.03 |
| 7 Paper | 1.49 | 1.55 | 1.03 |
| 8 Printing and publishing | 1.33 | 1.38 | 1.03 |
| 9 Petroleum and coal products | 1.35 | 1.53 | 1.03 |
| 10 Chemicals | 1.36 | 1.47 | 1.03 |
| 11 Plastic and rubber products | 1.46 | 1.52 | 1.03 |
| 12 Non-metallic mineral product | 1.46 | 1.51 | 1.03 |
| 13 Primary metal | 1.48 | 1.56 | 1.03 |
| 14 Fabricated metal | 1.48 | 1.56 | 1.03 |
| 15-16 Machinery and computer* | 1.38 | 1.46 | 1.03 |
| 15 Machinery | 1.38 | 1.46 | 1.03 |
| 16 Computer | 1.35 | 1.41 | 1.03 |
| 17-19 Electronic and electrical equipment | 1.35 | 1.41 | 1.03 |
| 17 Communications equipment | 1.35 | 1.41 | 1.03 |
| 18 Other electronic equipment | 1.35 | 1.41 | 1.03 |
| 19 Electrical equipment | 1.35 | 1.41 | 1.03 |
| 20 Motor vehicle | 1.42 | 1.50 | 1.03 |
| 21 Other transportation equipment | 1.42 | 1.50 | 1.03 |
| 22 Furniture and related product | 1.40 | 1.51 | 1.03 |
| 23 Miscellaneous manufacturing | 1.31 | 1.38 | 1.03 |
| **Services Industries** | **1.17** | **1.33** | **1.03** |
| 24 Utility | 1.20 | 1.40 | 1.03 |
| 25 Wholesale trade | 1.27 | 1.32 | 1.03 |
| 26 Retail trade | 1.22 | 1.39 | 1.03 |
| 27 Transportation | 1.26 | 1.36 | 1.03 |
| 28 Information and cultural industries | 1.21 | 1.28 | 1.03 |
| 29 FIRE | 1.19 | 1.34 | 1.03 |
| 30 Business services | 1.26 | 1.30 | 1.03 |
| 31 Other services | 1.11 | 1.31 | 1.04 |
| **Business Sector** | **1.20** | **1.37** | **1.03** |

* The estimates for machinery (15) are used for the combined industry given that the computer industry is relatively small and that the estimates for the two industries (machinery and computers) are very similar.

**Table 4: Productivity and Capital Intensity in Canada Relative to the United States., 1999 (United States =1)**

| Industry | Productivity | | Capital Intensity | |
|---|---|---|---|---|
| | Labour Productivity | MFP | M&E | Total Capital |
| **Primary Industries** | **0.84** | **0.76** | **0.42** | **1.17** |
| 1 Agriculture | 0.80 | 0.90 | 0.46 | 0.82 |
| 2 Mining | 1.07 | 0.85 | 0.37 | 1.40 |
| **Construction** | **1.20** | **1.19** | **1.03** | **1.04** |
| 3 Construction | 1.20 | 1.19 | 1.03 | 1.04 |
| **Manufacturing Industries** | **0.82** | **0.91** | **0.65** | **0.77** |
| 4 Food, beverage and tobacco | 0.77 | 1.04 | 0.46 | 0.55 |
| 5 Textile and clothing | 0.68 | 0.80 | 0.53 | 0.59 |
| 6 Wood product | 1.11 | 0.92 | 1.81 | 1.60 |
| 7 Paper | 1.17 | 0.99 | 1.35 | 1.50 |
| 8 Printing and publishing | 1.05 | 1.28 | 0.49 | 0.49 |
| 9 Petroleum and coal products | 0.48 | 0.47 | 0.35 | 1.08 |
| 10 Chemicals | 0.86 | 0.93 | 0.61 | 0.85 |
| 11 Plastic and rubber products | 0.74 | 0.86 | 0.62 | 0.63 |
| 12 Non-metallic mineral product | 1.14 | 1.22 | 0.76 | 0.84 |
| 13 Primary metal | 1.34 | 1.31 | 0.91 | 1.08 |
| 14 Fabricated metal | 0.51 | 0.66 | 0.35 | 0.47 |
| 15-16 Machinery and computers | 0.70 | 0.87 | 0.30 | 0.44 |
| 17-19 Electronic and electrical equipment | 0.63 | 0.98 | 0.33 | 0.37 |
| 20 Motor vehicle | 1.09 | 1.07 | 0.95 | 1.03 |
| 21 Other transportation equipment | 1.13 | 1.36 | 0.52 | 0.55 |
| 22 Furniture and related product | 0.71 | 0.86 | 0.48 | 0.51 |
| **Services Industries** | **0.79** | **0.83** | **0.50** | **0.86** |
| 24 Utility | 0.77 | 0.64 | 0.83 | 1.29 |
| 25 Wholesale trade | 0.71 | 1.05 | 0.20 | 0.26 |
| 26 Retail trade | 0.85 | 0.93 | 0.60 | 0.67 |
| 27 Transportation | 0.98 | 0.97 | 0.52 | 1.04 |
| 28 Information and cultural industries | 0.65 | 0.80 | 0.55 | 0.69 |
| 29 FIRE | 0.58 | 0.86 | 0.44 | 0.50 |
| 30 Business services | 0.79 | 0.96 | 0.32 | 0.39 |
| **Private Business Sector** | **0.82** | **0.86** | **0.55** | **0.89** |

Notes: Labour productivity is defined as value added per hour worked. The totals (bolded entries) except MFP are aggregated from their industries based on the trans-log aggregation formula as equation (3). The advantage of the bottom up approach is that it controls for the differences in industrial structures since the weights (labour shares for labour productivity and nominal capital stock shares for capital intensity) are the average of the two countries for each industry. MFP is calculated as a residual.

**Table 5: A Comparison of Current and Previous Estimates of Labour Productivity Levels in Canada Relative to the United States, 1999 (United States = 1)** *

| Industry | Current Estimates | Previous Estimates |
|---|---|---|
| **Primary Industries** | **0.84** | **0.64** |
| 1 Agriculture | 0.80 | 0.64 |
| 2 Mining | 1.07 | 0.70 |
| **Construction** | **1.20** | **0.98** |
| 3 Construction | 1.20 | 0.98 |
| **Manufacturing Industries** | **0.82** | **0.69** |
| 4 Food, beverage and tobacco | 0.77 | 0.84 |
| 5 Textile and clothing | 0.68 | 0.69 |
| 6 Wood product | 1.11 | 1.26 |
| 7 Paper | 1.17 | 1.20 |
| 8 Printing and publishing | 1.02 | 0.64 |
| 9 Petroleum and coal products | 0.48 | 0.39 |
| 10 Chemicals | 0.86 | 0.79 |
| 11 Plastic and rubber products | 0.74 | 0.93 |
| 12 Non-metallic mineral product | 1.14 | 1.02 |
| 13 Primary metal | 1.34 | 1.08 |
| 14 Fabricated metal | 0.51 | 0.71 |
| 15-16 Machinery and computers | 0.70 | 0.33 |
| 17-19 Electronic and electrical equipment | 0.63 | 0.24 |
| 20-21 Transportation equipment | 1.10 | 1.09 |
| 22 Furniture and related product | 0.71 | 1.03 |
| **Services Industries** | **0.79** | **0.79** |
| 24 Utility | 0.77 | 0.62 |
| 25 Wholesale trade | 0.71 | N.A. |
| 26 Retail trade | 0.85 | N.A. |
| 27 Transportation | 0.98 | 0.83 |
| 28 Information and cultural industries | 0.65 | 0.50 |
| 29 FIRE | 0.58 | N.A. |
| 30 Business services | 0.79 | N.A. |
| **Private Business Sector** | **0.82** | **0.84** ** |

* The current estimates are based on value added per hour worked, while the previous estimates are based on value added per worker. The previous estimates are derived from estimates in Rao, Tang and Wang (2003).
** The number is for the total economy.

**Table 6: Labour Productivity* in Canada and the United States: 1997-2001**

| | Labour Productivity Level in Canada (United States = 1.00) | | | Labour Productivity Growth (% per year) | |
|---|---|---|---|---|---|
| **Industry** | **1997** | **1999** | **2001** | **Canada** | **U.S.** |
| **Primary Industries** | **0.78** | **0.84** | **0.87** | **4.5** | **1.1** |
| 1 Agriculture | 0.74 | 0.80 | 0.84 | 6.7 | 3.3 |
| 2 Mining | 0.99 | 1.07 | 0.98 | -0.6 | -0.4 |
| **Construction** | **1.15** | **1.20** | **1.29** | **2.0** | **-0.9** |
| 3 Construction | 1.15 | 1.20 | 1.29 | 2.0 | -0.9 |
| **Manufacturing Industries** | **0.84** | **0.82** | **0.80** | **2.8** | **4.1** |
| 4 Food, beverage and tobacco | 0.75 | 0.77 | 0.99 | 2.4 | -4.3 |
| 5 Textile and clothing | 0.68 | 0.68 | 0.62 | 0.2 | 2.8 |
| 6 Wood product | 1.03 | 1.11 | 1.31 | 6.3 | 0.1 |
| 7 Paper | 1.07 | 1.17 | 1.23 | 1.1 | -2.2 |
| 8 Printing and publishing | 1.14 | 1.02 | 1.27 | 1.3 | -1.5 |
| 9 Petroleum and coal products | 0.68 | 0.48 | 0.61 | -1.5 | 1.1 |
| 10 Chemicals | 0.80 | 0.86 | 1.06 | 6.5 | -1.0 |
| 11 Plastic and rubber products | 0.76 | 0.74 | 0.77 | 2.8 | 2.4 |
| 12 Non-metallic mineral product | 1.06 | 1.14 | 1.38 | 3.6 | -2.9 |
| 13 Primary metal | 1.37 | 1.34 | 1.50 | 4.9 | 2.6 |
| 14 Fabricated metal | 0.47 | 0.51 | 0.52 | 1.5 | -0.8 |
| 15-16 Machinery and computers | 0.85 | 0.70 | 0.63 | 2.8 | 10.7 |
| 17-19 Electronic and electrical equipment | 0.66 | 0.63 | 0.44 | 6.0 | 17.5 |
| 20 Motor vehicle | 0.98 | 1.09 | 1.03 | 4.7 | 3.6 |
| 21 Other transportation equipment | 1.28 | 1.13 | 1.27 | 4.2 | 4.3 |
| 22 Furniture and related product | 0.67 | 0.71 | 0.73 | 2.0 | -0.1 |
| **Services Industries** | **0.79** | **0.79** | **0.81** | **2.1** | **1.9** |
| 24 Utility | 0.79 | 0.77 | 0.75 | -1.3 | 0.0 |
| 25 Wholesale trade | 0.73 | 0.71 | 0.69 | 4.0 | 5.5 |
| 26 Retail trade | 0.85 | 0.85 | 0.82 | 3.9 | 4.7 |
| 27 Transportation | 0.99 | 0.98 | 1.04 | 1.3 | 0.2 |
| 28 Information and cultural industries | 0.67 | 0.65 | 0.60 | 1.5 | 4.3 |
| 29 FIRE | 0.60 | 0.58 | 0.55 | 0.6 | 2.7 |
| 30 Business services | 0.78 | 0.79 | 0.86 | 2.8 | 0.3 |
| **Private Business Sector** | **0.83** | **0.82** | **0.82** | **2.5** | **2.8** |

*Value added per hour worked. The benchmark estimates are extended backward to 1997 and forward to 2001 using the annual labour productivity growth rates for both Canada and the United States for 1997-2001.

**Table 7: Relative Value-Added Price and Input Prices and MFP Levels in Canada (United States =1), 1999**

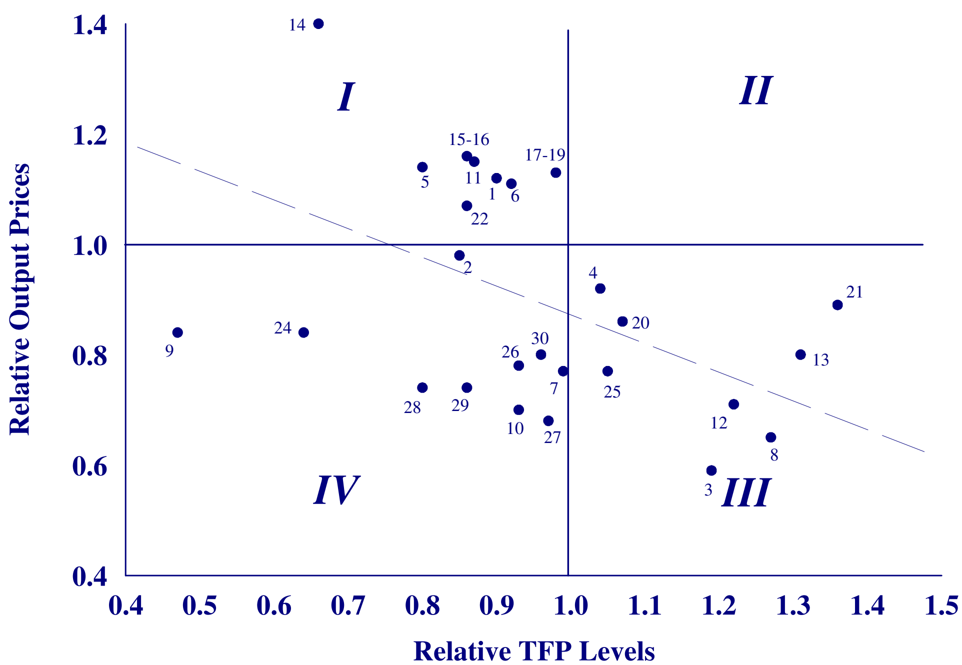
| Industry | Relative Value-added Price | Relative MFP | Relative Investment Prices | | | Relative Wage Rate |
|---|---|---|---|---|---|---|
| | | | Total | M&E | Struc. | |
| **Primary Industries** | **1.05** | **0.76** | **0.83** | **0.93** | **0.69** | **1.07** |
| 1 Agriculture | 1.12 | 0.90 | 0.87 | 0.92 | 0.69 | 1.03 |
| 2 Mining | 0.98 | 0.85 | 0.82 | 0.93 | 0.69 | 0.77 |
| **Construction** | **0.59** | **1.19** | **0.90** | **0.92** | **0.69** | **0.94** |
| 3 Construction | 0.59 | 1.19 | 0.90 | 0.92 | 0.69 | 0.94 |
| **Manufacturing Industries** | **0.94** | **0.91** | **0.95** | **1.00** | **0.69** | **0.66** |
| 4 Food, beverage and tobacco | 0.92 | 1.04 | 0.94 | 1.01 | 0.69 | 0.69 |
| 5 Textile and clothing | 1.14 | 0.80 | 0.95 | 0.99 | 0.69 | 0.66 |
| 6 Wood product | 1.11 | 0.92 | 0.93 | 1.01 | 0.69 | 0.92 |
| 7 Paper | 0.77 | 0.99 | 1.00 | 1.05 | 0.69 | 0.81 |
| 8 Printing and publishing | 0.65 | 1.28 | 0.90 | 0.93 | 0.69 | 0.70 |
| 9 Petroleum and coal products | 0.84 | 0.47 | 0.91 | 1.03 | 0.69 | 0.65 |
| 10 Chemicals | 0.70 | 0.93 | 0.91 | 0.99 | 0.69 | 0.54 |
| 11 Plastic and rubber products | 1.16 | 0.86 | 0.98 | 1.02 | 0.69 | 0.76 |
| 12 Non-metallic mineral product | 0.71 | 1.22 | 0.98 | 1.02 | 0.69 | 0.70 |
| 13 Primary metal | 0.80 | 1.31 | 1.00 | 1.05 | 0.69 | 0.83 |
| 14 Fabricated metal | 1.40 | 0.66 | 1.00 | 1.05 | 0.69 | 0.73 |
| 15-16 Machinery and computers | 1.15 | 0.87 | 0.93 | 0.98 | 0.69 | 0.63 |
| 17-19 Electronic and electrical equipment | 1.13 | 0.98 | 0.91 | 0.95 | 0.69 | 0.59 |
| 20 Motor vehicle | 0.86 | 1.07 | 0.96 | 1.01 | 0.69 | 0.66 |
| 21 Other transportation equipment | 0.89 | 1.36 | 0.96 | 1.01 | 0.69 | 0.67 |
| 22 Furniture and related product | 1.07 | 0.86 | 0.94 | 1.01 | 0.69 | 0.67 |
| **Services Industries** | **0.74** | **0.83** | **0.78** | **0.90** | **0.70** | **0.62** |
| 24 Utility | 0.84 | 0.64 | 0.81 | 0.94 | 0.69 | 0.49 |
| 25 Wholesale trade | 0.77 | 1.05 | 0.86 | 0.89 | 0.69 | 0.56 |
| 26 Retail trade | 0.78 | 0.93 | 0.82 | 0.93 | 0.69 | 0.79 |
| 27 Transportation | 0.68 | 0.97 | 0.85 | 0.91 | 0.69 | 0.71 |
| 28 Information and cultural industries | 0.74 | 0.80 | 0.82 | 0.86 | 0.69 | 0.47 |
| 29 FIRE | 0.74 | 0.86 | 0.80 | 0.90 | 0.69 | 0.57 |
| 30 Business services | 0.80 | 0.96 | 0.85 | 0.88 | 0.69 | 0.74 |
| **Private Business Sector** | **0.77** | **0.86** | **0.81** | **0.92** | **0.69** | **0.66** |

Notes: Relative value-added price is value added PPP divided by the exchange rate; relative investment price is investment PPP divided by the exchange rate; and relative wage rate is the ratio of wage rate (in national currency) per hour in Canada to that in the United States, divided by the exchange rate.

**Figure 1**
**Relative labour Productivity in Canada, 1987-2003**
**(U.S.=1.0)**


Notes: Labour productivity is defined as real GDP per hour worked, PPP based. The series are derived by extending the estimates for 1999 from Table 4 using growth rates from Statistics Canada and U.S. Bureau of Labor Statistics.

**Figure 2**
**Relative Output Prices and Relative TFP Levels, 1999**




Note: Numbers in this figure refer to those industries listed in Table 1.