Capital Stock and Productivity: Some Measurement Issues.

Mahamat Hamit-Haggar

Major Paper submitted to the
Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of requirement
for the M.A. degree in Economics

Department of Economics
Faculty of Social Sciences
University of Ottawa

Abstract

This paper explores whether the effect of different measures of Canadian capital stock has a direct incidence on MFP growth in a panel of 39 business sector industries for the period 1987-2004. Using these three alternative measures, we calculate MFP growth and the estimates are compared with the United States' MFP growth data. Our findings suggest that using the three measures of Canadian capital stock to compute MFP yields substantially different results. Subsequently, when comparing these Canadian MFP growth rates with the United States MFP growth rate, results show that we have a significant MFP growth gaps. The MFP growth gaps between the Canadian and the United States manufacturing and business sectors can be accounted entirely by the spectacular increase in MFP in the Unites States high tech industry over the 1987-2004 periods.

Secondly, we analyze econometrically the relationship between inputs and outputs using time series and cross-section data contained in Canada and the United States industry level. We find that the production function framework does not provide an adequate picture of the relationship between inputs and outputs using industry level data. These results indicate that pooling across industries and through time provide limited information on the relationship between inputs and outputs.

Acknowledgments

First I am particularly thankful to my supervisor, Professor Serge Coulombe, for his strong support, valuable advice and well-organized guidance during this study. His encouragement and patience in helping me to improve this paper is much appreciated. I would also like to express my sincere gratitude to Industry Canada for its financial support and for granting me access to data. Thanks go also to Rao Someshwar, Richard Roy, Jianmin Tang and Weimin Wang for their valuable help during the writing of this paper. Constructive comments and suggestions from the participants at the presentation of this paper at Industry Canada are also acknowledged. I wish to thank as well Brigitte Robert and Stephen Su for their revision and correction of the paper.

Contents

I. Introduction

Before the first oil price shock of 1973, productivity growth and standards of living were relatively sustained in a majority of the Organization for Economic Co-operation and Development (OECD) economies. After the crisis, most countries were negatively affected by rising inflation, rising unemployment, and a productivity slowdown. Indeed, both Canada and the United States experienced a fall-off in their respective productivity growth. Furthermore, Canada's productivity started to grow notably slower than that of the United States. With the sluggish productivity performance, Canada's living standards began declining relative to the United States'. This situation has become a source of great worry to many observers and policymakers who seek explanation.

Since then, there have been a number of empirical studies devoted to understanding and determining the reasons for this differential productivity performance in Canada and the United States. (See Bernstein, 2000, Eldridge and Sherwood, 2001, Baldwin et al., 2001, Armstrong et al., 2002, Rao et al., 2006). Much of this research has focused on the hypotheses that productivity differences between Canada and the United States are related to differences in information and telecommunication technology (ICT), and in machinery and equipment (M&E) investments.

For example, Gu and Ho (2000) investigate the productivity performance of Canadian and American manufacturing sectors for the period 1961-1995. They separate the entire period into three distinct sub-periods with breakpoints in 1973 and 1979. They conclude that the growth rate of multifactor productivity in the two countries was almost similar during the period of 1961-1973. After 1973, multifactor productivity growth was relatively higher in the United States. Moreover, their study reveals that the poor performance observed in the Canadian high tech industries is responsible for the multifactor productivity growth gap during the period of 1979-1995.

It may be important to point out that some researches have attributed a large part of the recent productivity gains in the United States to the production and use of ICT. One such study to acknowledge this fact is that of Jorgenson, Ho and Stiroh (2001), who study the productivity growth in the United States' private sector during the period of 1995-2000. It is to be noted that the results of their research suggest that the production and the use of ICT was the driving force behind the recent improvement of productivity growth in the United States.

Using a panel data of 20 United States manufacturing industries over the period 1984-1999, Stiroh (2002) applies the growth regression techniques in order to determine the contribution of ICT capital into the output growth. His results suggest that ICT capital does not appear to be a driving force of the new economy as one should hope to see. In fact, ICT capital contributes negatively to output growth. Then, he examines the contribution by breaking down the ICT capital into computers (hardware and software) and telecommunications. The estimated coefficients are both negative with an insignificant coefficient on computers. Therefore, he did not omit to mention that the negative sign on ICT capital is potentially related to measurement error.

On the other hand, Rao et al. (2006) use Canadian and United States industry data to examine thoroughly the determinants of the Canada-United States' multifactor productivity level gap. They use a panel of 41 industries in the Canada and the United States over the period 1987-2003. Their conclusions indicate that M&E is the main determinant of the multifactor productivity level gap between Canada and the United States. Differences in trade openness and capacity utilization also matter.

However, multifactor productivity is properly measured if, and only if, the labour and capital inputs are also properly measured. Measurement issues may be more important for cross-country comparisons since capital and labour may not be measured in a consistent way in all countries. Measurement issues have been mentioned in most multifactor productivity studies[1] . In this context, Coulombe (2000) analyzes the productivity between Canada and the United States using business sector data since 1961. The purpose of his study is to verify whether the measured Canada-United States multifactor productivity and labour productivity gaps are real, or whether they might be due to differences in methodologies used by the two statistical agencies. The main conclusion which emerged from this study was that, compared with the United States, the procedure used by Statistics Canada overstates the multifactor productivity growth by nearly a quarter of a percentage point annually. Since then Statistics Canada has revised its methodologies to adopt a procedure that is supposed to be closer to the one used by the Bureau of Labor Statistics.

The first objective of this paper is to analyze and quantify how differences in the measurement of capital stock can impinge on the measurement of multifactor productivity. To this end, we compute multifactor productivity at the industry level by taking three different measures of Canadian capital stock. The results are compared with United States' multi-

---

1 See Stiroh (2002), Baldwin and Harchaoui (2001).

factor productivity data. The second objective of the paper is to test some basic assumption underlying multifactor productivity accounting using the time series and cross-section information contained in the Canada and United States industry data. For each country, we have 702 observations with 39 NAICS-based industries and a sample period 1987-2004. Among others, our data shows that the standard Cobb-Douglas production function does not adequately capture the relationship between inputs and outputs in the case of Canada-United States cross-industry data. Furthermore, statistical test rejects the constant returns to scale hypothesis.

The rest of the paper is organized as follows. The next section lays out the basic methodology of the neoclassical framework, in which we provide the two different approaches to implement the multifactor productivity: the growth accounting and the growth regression. Section 3 describes the data sources, variables and measures we use in our empirical evaluation. Section 4, presents the empirical results in three subsections: basic trends, graphical analysis and econometric analysis. The last section concludes..

II. Methodology

A common point of departure for many studies in growth accounting is the neoclassical production function. The essence of growth accounting was presented in Abramowitz (1956), Solow (1957), and Jorgenson and Griliches (1967). Solow's methodology became the cornerstone for an extensive research on growth accounting that has tried to identify the sources of economic growth. Following his seminal work, the aggregate production function takes the form:

$$Y_{i,t} = A_{i,t} K_{i,t}^{\alpha_{i,t}} L_{i,t}^{\beta_{i,t}}. \tag{2.1}$$

Where $Y_{i,t}$ are the flow of output produced by the *i*'s industry at time *t*, (output measured by the value added in our case), $K_{i,t}$ are the net capital stock accumulated at time *t*, by industry *i*, $L_{i,t}$ are the quantity of labour enrolled in production at time *t* by industry *i* and $A_{i,t}$ are the level of technology also known as multifactor productivity (MFP). The main objective of growth accounting is to decompose economic growth into separate contributions from capital, labour and the residual or MFP. Taking logarithms of the production function yields:

$$\log Y_{i,t} = \alpha_{i,t} \log K_{i,t} + \beta_{i,t} \log L_{i,t} + \log A_{i,t}. \tag{2.2}$$

The growth rate of aggregate output can be found by taking the difference through time and assuming that the $\alpha_{i,t}$ and the $\beta_{i,t}$ are constant through time yields:

$$\log \frac{Y_{i,t}}{Y_{i,t-1}} = \alpha_{i,t} \log \frac{K_{i,t}}{K_{i,t-1}} + \beta_{i,t} \log \frac{L_{i,t}}{L_{i,t-1}} + \log \frac{A_{i,t}}{A_{i,t-1}}. \tag{2.3}$$

Thus, multifactor productivity growth is obtained after subtraction from the growth rate of aggregate output, the weighted rate of growth of factor inputs, where the weights are the corresponding output elasticities. This gives us:

$$MFPG_{i,t} = g_{y_{i,t}} - \alpha_{i,t} g_{k_{i,t}} - \beta_{i,t} g_{l_{i,t}}. \tag{2.3'}$$

Where $g_{y_{i,t}}$ denotes the growth rate of aggregate output, $g_{k_{i,t}}$ denotes the growth rate of stock of capital and $g_{l_{i,t}}$ is indeed the growth rate of labour. Note that it is also assume the production function exhibits constant returns to scale such that: ($\alpha_{i,t} + \beta_{i,t} = 1$).

It is important to note that although elasticities are not directly observable, under the assumption of perfect competition among firms in the economy, inputs shares are good candidates to be substitutes for output elasticities. To be more specific, consider the profit maximization problem of the firm using a Cobb-Douglas production function where capital is rented at market price $r_{i,t}$ and workers are hired at wage $w_{i,t}$. Here, we normalize the price of output to one. The maximization problem is:

$$\underset{K_{i,t},L_{i,t}}{Max}\ A_{i,t} K_{i,t}^{\alpha_{i,t}} L_{i,t}^{\beta_{i,t}} - r_{i,t} K_{i,t} - w_{i,t} L_{i,t}. \tag{2.4}$$

And the first order conditions are:

$$\alpha_{i,t} A_{i,t} K_{i,t}^{\alpha_{i,t}-1} L_{i,t}^{\beta_{i,t}} - r_{i,t} = 0, \ \ \beta_{i,t} A_{i,t} K^{\alpha_{i,t}} L_{i,t}^{\beta_{i,t}-1} - w_{i,t} = 0.$$

Given expressions above, we can compute the fraction of output used to pay capital and labour respectively as:

$$\alpha_{i,t} = \frac{r_{i,t} K_{i,t}}{Y_{i,t}} \text{ and } \beta_{i,t} = \frac{w_{i,t} L_{i,t}}{Y_{i,t}}. \tag{2.5}$$

Equation (2.5) shows clearly that, if there is perfect competition among firms, output elasticities will equal the income share of inputs in national accounting. Practically speaking, the labour share is assumed to equal the share of wages in national income. The capital share is then assumed to equal 1- the labour share. This follows from our assumption of constant returns to scale. Therefore, the average capital share in the business sector is 0.34 for Canada and 0.36 for United States during the period of 1987-2004. These shares are close to the 1/3 benchmark number observed in most industrialized economies. Thereby, the contribution of capital stock on output growth is proportional to its share in output. Obviously, if the growth of capital stock increases by 1% for instance in the given year, this would increase the growth of output by 0.34% and 0.36% respectively in Canada and the United States. As a result, growth in labour input has bigger impact on output. In our empirical analysis, we will also decompose capital stock into machinery & equipment capital and structure capital.

Ultimately, equation (2.2) and (2.3') have been widely used in the growth literature. Equation (2.3') can be computed given data on income share as in growth accounting. Equation (2.2) can be estimated using econometrics and MFP can be viewed as the residual of the regression. In estimating the equation below with time-series and cross-section data (TSCS), α the and β are assumed to be constant thought time and across industries. The TSCS model is:

$$y_{i,t} = \beta_1 k_{i,t} + \beta_2 l_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t}. \tag{2.6}$$

Where lower case letters stand for log-variables in the specification of the equation (2.2). In this case, multifactor productivity can be viewed as:

$$MFP_{i,t} = \mu_i + \gamma_t + \varepsilon_{i,t.} \tag{2.7}$$

μ_i are the unobserved industry specific effects, γ_t are the period specific effects and $\varepsilon_{i,t}$ are the idiosyncratic errors. Diverse econometric methods can be considered to estimate equation (2.6), statically or dynamically.

In this paper, we estimated the static representation by Panel Least Square (PLS) but we adopt the approach recommended by Beck and Katz (1995) by replacing the usual standard errors with the panel-corrected standard errors. To the best of our knowledge, no other attempt has been done to estimate the equation (2.6) following the growth regression for the Canada and United States using industry panel data.

III. Data

This paper uses data from two main sources: Statistics Canada (STC) and the Bureau of Economic Analysis (BEA). Annual data is used for Canada and United-States. The period is from 1987-2004. In the case of Canada, we have three alternative measures of capital stock denoted respectively by Capital1, Capital2 and Capital3. We also decompose the capital stock in two components: machinery & equipment and structures. Capital1 is the measure of capital used by Rao et al. (2006); Capital2 is the special tabulation from Statistics Canada. This capital was constructed especially for Industry Canada based on the previous methodology but under a new type of data. The difference between the two methodologies is that the former has a higher depreciation rate. And Capital3 is from STC CANSIM table 031-0002. It is in chained-Fisher dollars, private fixed non-residential geometric end-year net capital stock.

Both Canada and United States calculate capital stock following the perpetual inventory technique. However, in the United States the methodology of the Bureau of Labor Statistics (BLS) differs from that of the Bureau of Economic Analysis (BEA). The BLS assumes that the efficiency pattern follows a hyperbolic distribution while BEA assumes a geometric distribution. The geometric distribution assumes that the rate of depreciation is constant. Therefore, the United-States capital stock series are fixed asset table from the Bureau of Economic Analysis (BEA).

For the employment data, number of jobs from STC and number of persons engaged in the production process from BEA are used respectively in this study.

The Canadian employment data are from STC CANSIM table 383-0010, which covers the years from 1997 onward. These data are extrapolated back to 1987 using the growth rates of the total number of jobs from STC CANSIM table 383-0003. STC CANSIM table 383-0003 is SIC-based, but in term of growth, SIC-based are similar to NAICS-based. The employment data for the United States represents the number of persons engaged in production. The source for the data from 1998 onward is the BEA NAICS-based GDP-by-industry tables, which is extended back to 1987 using the growth rates of the number of persons engaged in production from the BEA1987 SIC-based GDP-by-industry tables.

Usually, BEA measures GDP at market prices and STC measures GDP at basic price, the main differences between the two measures reside in the treatment of taxes and subsidies. But for the bilateral productivity comparisons, a value-added measure of GDP at factor cost is used in this paper. GDP at factor cost is more appropriate in the case of industrial productivity comparisons. Hence, GDP at factor cost in 1999 for Canada is obtained from STC CANSIM table 381-0013. The imputed value for owner-occupied dwellings is not included.

The time series of GDP at factor cost in 1999 dollar is estimated using the growth rates of GDP at basic price in 1997 chained-Fisher dollar. The GDP at basic price in 1997 chained-Fisher dollar from 1997 onward come from STC CANSIM table 379-0017, which are extended back to 1987 using the growth rates of GDP at factor cost in 1992 constant dollar from STC CANSIM table 379-0001. The capital share of income is calculated using the data from STC CANSIM table 381-0013. GDP at factor cost in 1999 for the U.S. is calculated using the data from BEA NAICS-based GDP-by-industry tables. The imputed value for owner-occupied dwellings is excluded using BEA NIPA table 7-12. The time series of GDP at factor cost in 1999 dollar are estimated using the chained-Fisher quantity index for GDP at market price from BEA NAICS-based GDP-by-industry tables. The capital share of income is calculated using the same source tables[2].

In comparing productivity between Canada and the United States, a key issue is how to convert value added and physical capital into common currency units. Conceptually, the appropriate rate of exchange is a purchasing power parity (PPP), indeed we use PPP values from Rao et al. (2004) to convert the Canadian unit into United States dollars.

2 Our main data and data description are from Rao et al;(2006), for more detail see the paper.

IV. Empirical results

4.1 Basic trends

4.1.1 Capital stock

In the attempt to measure productivity growth, the measure of inputs of any given production function is crucial. Economists and statisticians acknowledge that mismeasured inputs reflect on multifactor productivity. In the first part of our empirical study, we briefly analyze to what extent using the three different measures of the Canadian capital stock, namely, Capital1, Capital2 and Capital3 matters for the measurement of multifactor productivity growth. Note that this designation of capital stock will be used throughout the paper.

Tables 1 through 3 present results on the average annual growth rates of our three measures of Canadian capital stock and the United States' capital. Table 1 results deal with the total capital stock (total of all components) and Tables 2 and 3 deal with machinery & equipment and structures respectively.

Table 1 shows the result of total capital stock in the entire business sector. Over the full 1987-2004 period, Capital1 grew at an average annual rate of 2.80% per year; Capital2 grew at an average annual rate of 2.19%, slightly higher than the growth rate of Capital3, which was 1.94%; and the United States' capital grew at an average annual rate of 1.87%.

Table 1: Capital stock in the Business Sector

Industry	Average annual growth rate, in percent Period 1987-2004			
	Capital1	**Capital2**	**Capital3**	**U..S.**
Primary	**0.57**	**0.46**	**0.33**	**-0.06**
Crop, Animal production	-0.80	-1.00	-0.85	0.02
Forestry,Fishing and related Activities	-0.61	-0.66	-1.07	0.46
Oil and gas extraction	3.94	4.47	4.29	-0.03
Mining (except Oil and gas extraction)	-0.30	-1.10	-1.37	-0.25
Support activities for Mining	1.67	1.58	1.55	-0.81
Construction	**4.00**	**3.43**	**3.95**	**4.22**
Manufacturing	**1.68**	**0.93**	**0.54**	**1.26**
Food, beverage, Tobacco	1.49	0.77	0.59	0.69
Textiles	-0.58	-1.24	-1.75	-0.79
Clothing and Leather	0.05	-1.11	-1.58	0.44
Wood	2.15	2.11	1.52	0.12
Paper	1.20	-0.94	-1.15	0.25
Printing and related Activities	2.41	1.45	1.24	1.76
Petroleum and coal	0.74	0.37	0.07	0.03
Chemicals	0.97	-0.40	-0.84	2.30
Plastics and rubber	3.37	3.25	2.72	2.65
Non-metallic	0.35	0.78	0.00	0.25
Primary Metal	0.65	-0.84	-1.19	-1.24
Fabricated Metal	1.08	0.61	0.03	1.02
Machinery	2.50	2.37	1.74	3.21
Computer and electronic	3.31	1.55	1.63	4.04
Electronic Equipment	1.66	0.55	0.05	0.93
Transportation Equipment	2.86	2.46	2.22	2.59
Furniture and related product	3.40	3.93	3.44	3.13
Miscellaneous	3.31	1.95	1.69	1.02

The growth rates of the three measures of the Canadian capital in the primary sector were 0.57%, 0.46% and 0.33% respectively, compared to the growth rate of -0.06% in the United States. Within the primary sector, the growth rates of the three measures of Canadian capital stock post a negative sign in the crop and animal production, in the forestry, fishing and related activities, and in mining (except oil and gas extraction). The growth rates of capital stock in the remaining industries that compose the primary sector were positive in Canada and negative in the United States. Oil and gas extraction is the main contributor to Canada's primary sector, with growth rates of 3.94%, 4.47% and 4.29% in Canada compares to negative growth of 0.03 in the United States.

In the construction sector, the growth rates of the three measures of Canadian capital stock and the United States' capital stock are 4.00%, 3.43% and 3.95% in Canada, in comparison to 4.22% in the United States.

The manufacturing sector is the sector of greatest interest. In this sector, the growth rates of capital stock were more widely distributed. Some industries exhibit positive growth rates while others post decline. In textiles, all three measures of Canadian capital as well as the United States' capital stock showed negative growth rates. However, the negative growth rates of capital stock were more pronounced with the measures of Capital2 and Capital3 than with Capital1 and the United States' capital stock. Four industries: clothing and leather, paper, chemicals, and primary metal, also showed negative growth rates with Capital2 and Capital3, but positive with Capital1. With respect to the manufacturing sector as a whole, total capital stock posted growth rates of 1.68%, 0.93% and 0.54% respectively in Canada and 1.26% in the United States.

In the services sector, growth rates of capital stock were respectively, 4.88%, 4.22%, 4.06% in Canada and 3.18% in the United States. Within the services, only the rail transportation presented a negative sign of growth rate. In the Utilities, negative growth rates were observed with the measures of Capital2 and Capital3, but positive with Capital1 and the United States' capital. In the remaining industries, positive growth rates performances were reported in both countries. .

Table 1: Capital stock in the Business Sector (cont)

	Average annual growth rate, in percent Period 1987-2004			
Industry	**Capital1**	**Capital2**	**Capital3**	**U..S.**
Services	**4.88**	**4.22**	**4.06**	**3.18**
Utilities	2.06	-0.08	-0.04	1.23
Wholesale Trade	5.58	5.85	5.67	3.30
Retail Trade	4.60	5.43	4.85	2.97
Rail Transportation	-0.38	-1.24	-1.44	-0.74
Truck Transportation	6.07	5.88	5.71	2.24
Warehousing and Storage	1.71	0.62	0.44	1.76
Other Warehousing and Transportation	3.38	3.15	2.78	2.39
Information and Cultural Industries	4.64	4.31	3.02	4.20
F.I.R.E, Management	3.54	2.31	2.79	4.23
Professional Scientific and Tech Service	17.67	14.68	14.75	7.81
Administrative and Support Services	9.79	7.99	8.60	8.37
Waste Management	5.36	5.48	5.34	1.29
Other Services (except Public Adm)	4.43	4.50	4.43	2.62
Business Sector	**2.80**	**2.19**	**1.94**	**1.87**

Table 2 presents the growth rates of machinery & equipment in the business sector. There is a noteworthy difference in terms of growth between the three measures of machinery & equipment for Canada. Over the period 1987-2004, the three measures of machinery & equipment in the entire business sector have grown by about 4.69%, 3.56% and 3.30% respectively in Canada, somewhat greater than the United States' growth rate which is 2.55%. .

Table 2: Capital stock ,M&E in the Business Sector

Industry	Average annual growth rate, in percent Period 1987-2004			
	Capital1	**Capital2**	**Capital3**	**U.S.**
Primary	**1.35**	**1.17**	**1.37**	**-0.17**
Crop, Animal production	-2.86	-2.05	-1.62	0.93
Forestry,Fishing and related Activities	-0.15	-1.45	-1.65	-0.94
Oil and gas extraction	6.02	5.13	5.92	-1.35
Mining (except Oil and gas extraction)	-1.72	-1.80	-1.77	0.23
Support activities for Mining	9.99	10.11	10.00	-0.16
Construction	**4.72**	**4.47**	**5.30**	**5.86**
Manufacturing	**3.02**	**1.93**	**1.45**	**1.79**
Food, beverage, Tobacco	2.68	1.85	1.73	1.41
Textiles	-0.58	-1.00	-1.52	-0.58
Clothing and Leather	1.77	-0.09	-0.75	1.56
Wood	2.67	2.38	1.85	0.63
Paper	1.24	-1.51	-1.64	0.29
Printing and related Activities	3.11	1.68	1.53	1.97
Petroleum and coal	7.13	7.58	6.38	0.50
Chemicals	0.95	-0.84	-1.44	2.60
Plastics and rubber	4.84	4.50	3.90	3.18
Non-metallic	1.48	1.81	0.99	0.92
Primary Metal	0.72	-0.38	-0.93	-0.96
Fabricated Metal	2.05	1.47	0.70	1.55
Machinery	4.55	3.70	2.95	3.99
Computer and electronic	4.61	2.00	2.18	4.94
Electronic Equipment	3.75	1.67	1.01	0.39
Transportation Equipment	3.78	3.57	3.24	3.05
Furniture and related product	6.73	5.28	5.06	4.90
Miscellaneous	5.34	2.82	2.54	1.91

In examining the variations in growth rates of machinery & equipment in the primary sector, it can be seen that the crop and animal production, forestry, fishing and related activities, as well as mining (except oil and gas extraction), have demonstrated weak growth rates while the support activities for mining has shown great performance in Canada. The oil and gas extraction industry is the second contributor to the Canada primary sector with growth rates of 6.02%, 5.13% and 5.92% respectively and -1.35% in the United States.

Over all, the primary sector indicates growth rates of 1.35%, 1.17%, and 1.37% in Canada and -0.17% in the United States.

In the construction sector, growth rates of 4.72%, 4.47%, and 5.30%, were respectively registered in Canada and 5.86% in the United States.

During the same period, the manufacturing sector has witnessed varying rates of growth among the three measures of machinery & equipment. For instance, growth rates of 3.02%, 1.93% and 1.45% in Canada, whereas the United States' achieved an average growth rate of 1.79%. In a similar manner with respect to the difference in terms of growth rate observed in the manufacturing sector, the sub-manufacturing sector reflects uneven growth rates among industries.

Table 2: Capital stock , M&E in the Business Sector (cont)

	Average annual growth rate, in percent Period 1987-2004			
Industry	**Capital1**	**Capital2**	**Capital3**	**U.S.**
Services	**7.92**	**6.22**	**6.04**	**4.27**
Utilities	2.75	-0.98	-0.77	1.11
Wholesale Trade	10.12	8.18	8.47	4.56
Retail Trade	8.05	6.79	6.57	4.61
Rail Transportation	-0.34	-0.17	-0.89	-2.78
Truck Transportation	7.54	7.36	7.01	1.55
Warehousing and Storage	5.57	5.36	4.49	5.04
Other Warehousing and Transportation	5.11	4.66	3.95	2.79
Information and Cultural Industries	6.63	6.48	3.71	5.68
F.I.R.E, Management	7.26	5.67	6.72	7.19
Professional Scientific and Tech Service	20.23	15.79	15.87	11.02
Administrative and Support Services	10.67	7.71	8.84	12.00
Waste Management	10.41	5.94	6.46	0.63
Other Services (except Public Adm)	13.77	10.93	11.37	1.53
Business Sector	**4.69**	**3.54**	**3.30**	**2.55**

Finally, in comparing the growth rates in the services sector, we have seen that only rail transportation has shown negative growth rates with the three measures of Canadian machinery & equipment. The utilities reported negative growth rates with machinery & equipment related to Capital2 and Capital3 and positive with the remaining capitals. It should be also noted that overall the services sector reported growth rates of 7.92%, 6.22% and 6.04% in Canada and 4.27% in the United States.

Table 3: Capital stock structure in the Business Sector

	Average annual growth rate, in percent Period 1987-2004			
Industry	**Capital1**	**Capital2**	**Capital3**	**U.S.**
Primary	**0.61**	**0.48**	**0.23**	**-0.09**
Crop,Animal production	-0.01	-0.51	-0.52	-0.67
Forestry,Fishing, Activities	-0.79	-0.13	-0.66	3.00
Oil and gas extraction	3.84	4.40	4.11	0.09
Mining (except Oil and gas extraction)	-0.10	-0.93	-1.26	-0.55
Support activities for Mining	0.62	-0.12	-0.27	-2.00
Construction	**2.49**	**1.53**	**1.46**	**0.47**
Manufacturing	**0.76**	**-0.40**	**-0.70**	**0.59**
Food, beverage, Tobacco	0.58	-0.92	-1.09	-0.05
Textiles	-0.58	-1.86	-2.31	-1.03
Clothing and Leather	-0.75	-2.57	-2.71	-0.35
Wood	1.54	1.58	0.90	-0.36
Paper	1.13	0.50	0.08	0.15
Printing and related Activities	1.32	0.62	0.21	1.36
Petroleum and coal	-0.60	-2.35	-2.59	-0.61
Chemicals	0.99	0.03	-0.18	1.98
Plastics and rubber	1.38	-0.08	-0.37	1.59
Non-metallic	-0.89	-1.28	-1.86	-0.63
Primary Metal	0.58	-1.65	-1.65	-1.63
Fabricated Metal	0.26	-1.05	-1.26	0.15
Machinery	1.28	0.38	-0.08	1.89
Computer and electronic	2.18	0.73	0.55	2.93
Electronic Equipment	0.15	-1.65	-1.80	1.54
Transportation Equipment	1.61	-0.36	-0.38	1.98
Furniture and related product	1.68	2.42	1.57	1.34
Miscellaneous	2.14	0.68	0.44	0.17

Up to now, we have discussed differences in terms of growth rates of the total capital stock and machinery & equipment. Let us now consider the growth rates of structures in the entire business sector. As stated in Table 3, growth rates in the entire business sector were 1.86%, 1.04% and 0.73% in Canada in comparison to 1.10% in the United States.

In the primary sector, the crop and animal production, the forestry, fishing and related activities and the mining (except oil and gas extraction) industries are those for which growth over the 1987-2004 interval failed to accelerate with all the three measures of Canadian structures. The support activities for mining reported positive growth rates with capital1 and negative with capital2 and 3, the oil and gas extraction remains the first contributor to the Canadian primary sector.

In the manufacturing sector, structure related to Capital2 and 3 shows growth rates of -0.40% and -0.70% respectively while structure related to Capital1 and the United States' capital have shown positive growth rates of 0.76% and 0.59% respectively.

Within the manufacturing sector, ten industries displayed negative growth rates with structure related to capital2 and 3 While, five industries with negative growth rates were observed when the growth rates of the total capital stock and machinery & equipment in the manufacturing sector were reported.

Table 3: Capital stock, structure in the Business Sector(cont)

Industry	Average annual growth rate, in percent Period 1987-2004			
	Capital1	**Capital2**	**Capital3**	**U.S.**
Services	**3.53**	**2.79**	**2.48**	**2.21**
Utilities	1.93	0.16	0.18	1.27
Wholesale Trade	3.74	3.94	3.30	1.12
Retail Trade	3.68	4.78	4.01	2.55
Rail Transportation	-0.38	-1.45	-1.56	-0.49
Truck Transportation	2.97	1.13	1.01	6.14
Warehousing and Storage	0.93	-0.62	-0.74	0.58
Other Warehousing and Transportation	2.83	2.47	2.22	1.70
Information and Cultural Industries	3.46	2.81	2.40	3.26
F.I.R.E, Management	2.45	0.16	0.43	2.85
Professional Scientific and Tech Service	13.82	12.37	11.76	2.78
Administrative and Support Services	8.75	8.52	8.13	3.18
Waste Management	3.20	5.01	4.17	1.52
Other Services (except Public Adm)	3.45	2.31	1.96	3.01
Business Sector	**1.86**	**1.04**	**0.73**	**1.10**

Finally, the rail transportation is the only industry in the services sector which posted negative growth rates with the three measures of Canada structure as well as the United States structure. The warehousing and storage shows negative growth rates with structure related to capital2 and 3 and positive with the two others capitals.

These differences have a direct incidence on the multifactor productivity growth rates, as well as the labour productivity growth. Therefore, one benefit of analyzing the growth rate of capital stock is that it provides us with the entire information about its impact on labour productivity, and at the same time, on multifactor productivity.

4.1.2 Multifactor productivity

Multifactor productivity relates an index of output to an index of the combination of inputs used in the production of that output. It measures the influences on economic growth that are due to technological progress, improvements in the efficiency of government regulation, literacy and skills of the workforce, returns to scale, reallocation of resources and other factors that could contribute to improve the production process. From an accounting point of view, multifactor productivity is simply derived as the difference in the rate of change of output minus a weighted change in inputs such a labour and capital.

In the subsequent discussion, we provide an overview of the multifactor productivity growth performance in the entire business sector in Canada and the United States during the period 1987-2004. In particular, we calculate the multifactor productivity growth performance in Canada and the United States; and we observed that the measured multifactor productivity growth rates dropped off sharply in many Canadian three-digit industries.

From 1987-2004, multifactor productivity grew at average rates of 1.17%, 1.38% and 1.48% in the Canadian business sector, compared to 1.80% in the United States. With our three alternative measures of the Canadian capital stocks, the multifactor productivity growth gaps range from 18% to 35% in the business sector.

Table 4 shows the average annual growth rates for the entire business sector and the different major sectors: primary, construction, manufacturing and services.

Table 4: Multifactor Productivity in the Business Sector

Industry	Capital1	Capital2	Capital3	U.S.
	Average annual growth rate, in percent Period 1987-2004			
Primary	**1.77**	**1.80**	**1.88**	**0.69**
Crop,Animal production	3.31	3.44	3.35	3.10
Forestry,Fishing and related Activities	0.82	0.83	0.96	-1.93
Oil and gas extraction	-0.91	-1.40	-1.25	-0.74
Mining (except Oil and gas extraction)	1.18	1.69	1.87	4.72
Support activities for Mining	4.48	4.47	4.48	-1.68
Construction	**0.36**	**0.43**	**0.37**	**-1.38**
Manufacturing	**1.55**	**1.77**	**1.93**	**2.57**
Food, beverage, Tobacco	0.34	0.72	0.81	0.95
Textiles	1.30	1.57	1.72	3.70
Clothing, Leather	-0.15	0.22	0.35	1.88
Wood	1.69	1.69	1.92	-0.38
Paper	1.27	1.89	2.08	0.54
Printing , related Activities	-0.67	-0.37	-0.32	-0.08
Petroleum and coal	2.06	1.75	1.91	0.49
Chemicals	2.75	3.55	3.81	1.13
Plastics and rubber	1.81	1.88	2.06	3.05
Non-metallic	1.34	1.11	1.47	3.04
Primary Metal	3.27	3.69	3.85	3.32
Fabricated Metal	1.40	1.51	1.69	1.26
Machinery	1.19	1.25	1.45	0.55
Computer and electronics	4.41	4.70	4.78	19.25
Electronic Equipment	0.18	0.45	0.66	1.71
Transportation Equipment	2.91	3.12	3.23	1.13
Furniture and related product	2.23	2.07	2.21	0.26
Miscellaneous	0.63	1.10	1.18	4.50

In the entire business sector, there was significant variation among industries in the average annual rates of the multifactor productivity growth. For example, Canada's multifactor productivity growth rates surpassed the American's in two major sectors for the period 1987-2004: in the primary and in the construction sectors which represent 3.08% of the overall business sector multifactor productivity growth in Canada.

In the primary sector, Canada dominates the United States with average annual growth rates of 1.77%, 1.80% and 1.88%, respectively, compared to 0.69% in the United States. In the crop and animal production, the multifactor productivity growth rates are quite similar: 3.31%, 3.44%, and 3.35% in Canada, and 3.10% in the United States.

Over all, within the primary sector, four out of five Canadian industries experienced multifactor productivity growth rates greater than their American counterparts. The United States surpassed Canada in mining (except oil and gas extraction), with a gain of 4.72% in comparison to 1.18%, 1.69% and 1.87% in Canada. In addition, oil and gas extraction reports negative growth rates in Canada and the United States.

With respect to the construction industry, classified at two digit level, Canada displayed extremely higher growth rates of multifactor productivity than the United States. The multifactor productivity growth rates were respectively 0.36%, 0.43% and 0.37% in Canada compared to a negative growth of -1.38% in the United States. One also notices similarities between growth rates of multifactor productivity computed with Capital1 and Capital3.

In the manufacturing sector, however, the average annual growth rates of multifactor productivity were 1.55%, 1.77% and 1.93% respectively in Canada, compared to 2.57% in the United States. The multifactor productivity growth gap in the manufacturing sector is important because of the contribution of the manufacturing sector into the business sector. The manufacturing sector's multifactor productivity growth accounts for around 70% of the business sector's multifactor productivity growth in Canada.

Our data show significant multifactor productivity growth gaps in the manufacturing sector. The United States has a multifactor productivity growth advantage of approximately 39 percentage points with Capital1 as input to compute multifactor productivity growth.

Our estimates show gaps of 31 and 25 percentage points, when Capital2 and Capital3 are used respectively to calculate the multifactor productivity growth.

There is also a wide dispersion in the multifactor productivity growth rates at the more detailed three-digit industry level. For instance, among the 18 industries which compose the manufacturing sector, 8 enjoyed higher multifactor productivity growth rates than their American counterparts. This is especially true for: wood, paper, petroleum and coal, chemicals, fabricated metal, machinery, transportation equipment, furniture and related products, regardless of which types of capital stock is used to compute the multifactor productivity growth rates. Amongst the 18 industries, negative multifactor productivity growth rates were recorded in printing and related activities, which contributes negatively to the manufacturing multifactor productivity growth.

It is noticeable that in Canada, the highest gain of the multifactor productivity growth occurred in the high tech industry. Computer and electronics has shown faster growth rates of multifactor productivity ranging from 4.41% to 4.78% in Canada, but it is far lower the one achieved in the United States high tech industry.

In fact, in the United States, the computer and electronics sector had a multifactor productivity growth of 19.25%, contributing for about 42 percentage points to the manufacturing multifactor productivity growth, and for around 28 percentage points to the business sector as a whole.

However, when the high tech industries are excluded from both manufacturing sectors, we find that relative multifactor productivity growth rates were 1.39%, 1.60%, 176% in Canada compared to 1.60% in the United States. Similarly, the multifactor productivity growth rates at the business sector level were 1.08%, 1.30%, 1.39% respectively in Canada and 1.31% in the United States.

Thus, computer and electronics seem to be the main contributor to the overall multifactor productivity growth over the period 1987-2004. So far, it is widely recognized, that the recent performance in the information and telecommunication technology in the United States is behind the widening of the multifactor productivity growth gap in the manufacturing and business sectors between the two countries.

Table 4: Multifactor Productivity in the Business Sector (cont)

	Average annual growth rate, in percent Period 1987-2004			
Industry	**Capital1**	**Capital2**	**Capital3**	**U.S.**
Services	**0.48**	**0.76**	**0.79**	**1.41**
Utilities	-1.61	0.00	-0.03	1.66
Wholesale Trade	1.56	1.50	1.54	3.13
Retail Trade	1.19	1.14	1.05	3.05
Rail Transportation	5.03	5.35	5.27	3.32
Truck Transportation	1.99	2.09	2.06	1.65
Warehousing and Storage	2.16	2.43	2.48	3.25
Other Warehousing,Transportation	-0.54	-0.48	-0.37	1.87
Information and Cultural Industries	-0.12	0.02	0.68	3.36
F.I.R.E, Management	0.62	1.18	0.96	-0.39
Professional Scientific and Tech Service	-2.42	-1.98	-1.98	-0.95
Administrative and Support Services	-1.48	-1.21	-1.3	0.09
Waste Management	-0.93	-0.99	-0.95	0.17
Other Services (except Public Adm)	0.89	0.89	0.89	-1.91
Business Sector	**1.17**	**1.38**	**1.48**	**1.80**

Let us turn now to the Canadian multifactor productivity growth performance in the services sector. In general, we can assert that the multifactor productivity growth was slower in Canada than in the United States. Canada recorded multifactor productivity growth rates of 0.48%, 0.76% and 0.79% respectively, in the services sector, compared to 1.41% in the United States.

The multifactor productivity growth gap in services sector is wider; it ranges from 44 to 65 percentage points while the services sector represent 27% of the business sector's multifactor productivity growth in Canada. However, we should not forget to note that growth in the services sector is not easy to capture, as it is the hardest measure to quantify for the output in this sector.

Nevertheless, we can affirm that Canada outperformed the United States in only four out of thirteen industries, especially in: rail transportation, truck transportation, F.I.R.E and management, and in other services (except public administration). Two services contribute negatively to the services sector: other warehousing, transportation, administrative, and support services.

4.1.3 Labour productivity

According to our data, labour productivity in the business sector grew faster in the United States than in Canada during the period 1987-2004. As reported in Table 5, over all, the United States surpasses Canada in two major sectors: in the manufacturing and the services industries.

Table 5: Labour productivity in the Business Sector

Average Annual growth rate, in percent
Period 1987-2004

Industry	Canada	United States
Primary	**2.91**	**0.85**
Crop, Animal production	4.25	3.81
Forestry, Fishing, related Activities	0.88	-3.27
Oil and gas extraction	3.23	0.01
Mining (except Oil, gas extraction)	2.06	5.57
Support activities for Mining	4.16	-1.85
Construction	**0.78**	**-0.63**
Manufacturing	**2.08**	**3.40**
Food, beverage, Tobacco	1.36	1.72
Textiles	1.44	4.38
Clothing, Leather	0.32	4.02
Wood Manufacturing	1.82	-0.41
Paper	2.03	1.15
Printing and related Activities	-0.26	0.57
Petroleum and coal	3.15	1.69
Chemicals	3.65	2.67
Plastics, rubber	2.00	4.04
Non-metallic	1.57	3.33
Primary Metal	3.60	3.38
Fabricated Metal	1.01	1.71
Machinery	1.50	1.69
Computer, electronics	6.05	20.26
Electronic Equipment	0.96	2.82
Transportation Equipment	3.72	1.93
Furniture and related product	2.65	1.17
Miscellaneous	0.82	5.07

For the period 1987-2004, labour productivity growth in the United States manufacturing sector increased at a rate of more than 1/3 than that of the Canadian manufacturing sector. The United For the period 1987-2004, labour productivity growth in the United States manufacturing sector increased at a rate of more than 1/3 than that of the Canadian manufacturing sector. The United States benefited from a labour productivity growth of 3.4% versus 2.08% in Canada. The greater performance of the United States manufacturing sector is mainly the result of labour productivity growth in computer and electronics which presents a growth of 20.26%. The faster multifactor productivity growth in this sector also contributed to the faster labour productivity growth.

When the high tech industry is isolated from both manufacturing sectors; labour productivity growth rates in the manufacturing sector are 1.84% and 2.40%, in Canada and the United States respectively. The growth of labour productivity in the business sector as a whole is 1.78% in Canada and 2.06% in the United States. Productivity differentials are closer without the contribution of the high tech industry. Obviously, the high tech industry is the predominant source of growth in both countries.

During the 1987-2004 period, labour productivity growth gaps between Canada and the United States were 39 and 26 percentage points in manufacturing and the Business sector respectively. When the high tech industry is excluded from the sample the resulting gaps represent 23 and 13 percentage points in manufacturing and the Business sector. Thus, the growth gaps in manufacturing and the Business sector is directly accounted by the performance of the high tech industry.

However, within the manufacturing sector, Canada reported a growth rate of labour productivity greater than the United States on: wood, paper, petroleum and coal, chemicals, transportation equipment, and furniture and related products. .

Table 5: Labour productivity in the Business Sector (cont)

Industry	Average Annual growth rate, in percent Period 1987-2004 Canada	United States
Services	**1.25**	**2.08**
Utilities	-1.14	3.08
Wholesale Trade	2.47	3.94
Retail Trade	1.75	3.46
Rail Transportation	5.84	3.9
Truck Transportation	3.11	2.02
Warehousing and Storage	2.23	3.28
Other Warehousing and Transportation	-0.03	1.77
Information and Cultural Industries	0.84	5.04
F.I.R.E, Management	1.52	1.37
Professional Scientific and Tech Service	-0.27	0.38
Administrative and Support Services	-0.81	1.39
Waste Management	-0.37	-0.40
Other Services (except Public Adm)	1.20	-2.15
Business Sector	**1.89**	**2.57**

In the services sector, labour productivity grew by 1.25% per year over the period in Canada, while in the United States labour productivity grew by 2.08%. Canada's labour productivity growth was in good shape in five out of thirteen services sector industries. The rail transportation had a growth rate of 5.84%, compared to 3.9% in the United States. Canada has a net advantage in the truck transportation, the F.I.R.E, management, waste management and the other services (except public administration).

Finally, the Canadian performance was noticeable in the primary and the construction sectors. However, the positive labour productivity growth in these sectors is apparently not decreasing the labour productivity gap.

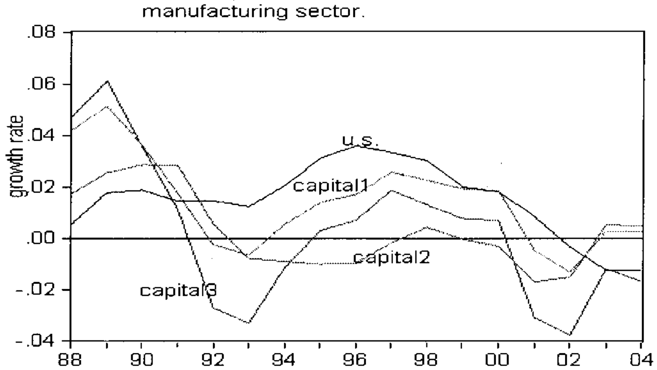
In sum, the United States' labour productivity growth performance in the business sector was spectacular over the period, with a growth of 2.57% compared to 1.89% in

Canada. Canada lagged behind the United States in productivity, with the labour productivity gap being 26 percentage points.

4.2 Graphical analysis

Figure 1 shows trends of net capital stock growth. There are substantial differences between the growth rates of the three measures of Canadian capital stock. The Capital3 series yield higher variation with standard deviation of 0.028 compared to 0.017 with capital1 and 0.014 with capital2. On the other hand, Capital1 shows the fastest growth rate, 1.72%, followed by the United States' capital 1.24%; Capital2 shows a growth rate of 0.98%, and finally Capital3 grew at 0.58% which is much lower than Capital1. The United States' capital shows a standard deviation of 0.014 which is comparable to Capital1 and 2..

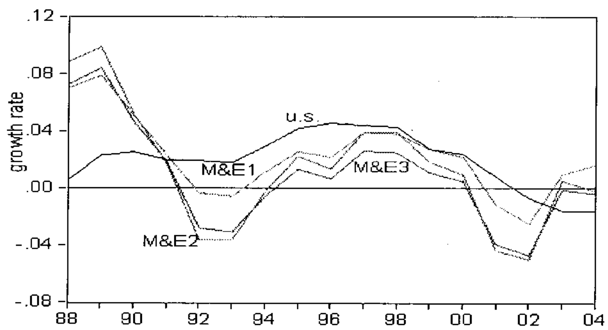
Figure 1 Annual growth rate, Total of all components in the manufacturing sector.



Note: Net capital Stock.

Figure 2 compares machinery & equipment in the manufacturing sector and their trends. Two conclusions are readily apparent. First, machinery & equipment related to Capital2 and Capital3 (standard deviation of 0.043 and 0.036 respectively) present higher variation than those related to Capital1 and the United States Capital (standard deviation of 0.024 and 0.019 respectively). Secondly, all machinery & equipment showed growth acceleration in the beginning of 1993 and decelerated in 2000.

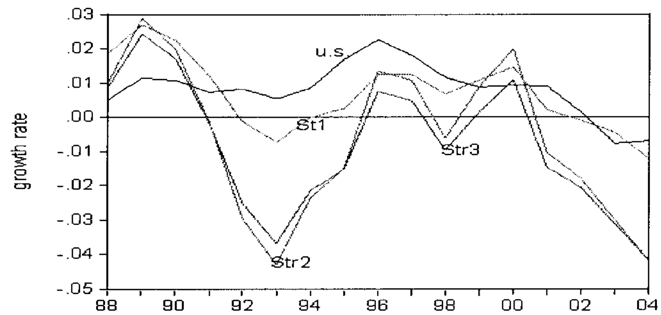
Figure 2 Annual growth rate, M&E in the manufacturing sector.



Note: M&E1,2,3 are related to capital 1,2,3 respectively.

Figure 3 shows trends for structure in the manufacturing sector. Structures related to Capital1 and the United States' capital show a standard deviation of 0.010 and 0.007 respectively. The growth rate of structure 2 and 3 are comparable with negative growth between 1991-1995, 1998 and after 2001. Their standard deviations are 0.022 and 0.019 respectively.

Figure 3 Annual growth rate, Strutrure in the manufacturing sector.



Note:Str1,2,3 are related to capital1,2,3 respectively.

Figure 4 and Figure 5 show respectively the level and growth graphs for capital-labour ratios. In terms of level, there is a difference between the three types of capital-labour ratios. However, the growth graph indicates that the three Canadian capital-labour ratios drop sharply during the 1988-1990 period and begin to fluctuate after 1992. The United States capital-labour ratio has shown low standard deviation during the period 1988-2004.

Figure 4: Level graph: Capital-labour-ratio

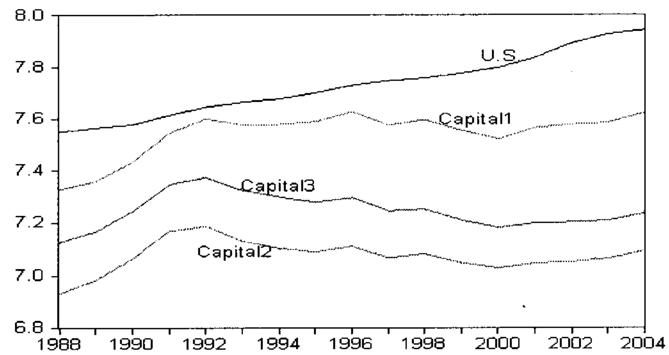
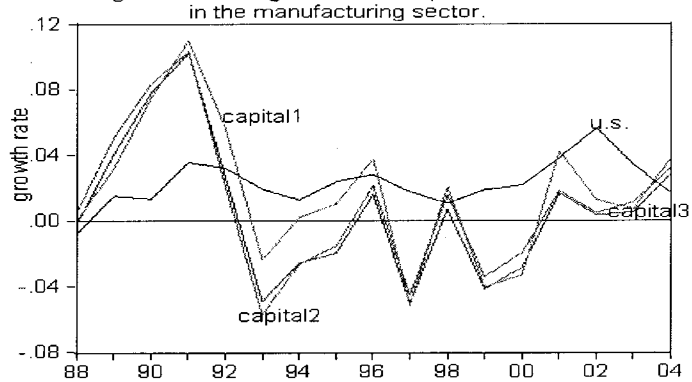


Figure5: Annual growth rate, capital-labour ratio in the manufacturing sector.



4.3 Econometric analysis

Table 6 (a) reports results from estimation of equation (2.6) over the period 1987-2004. Under this specification, output is taken as the dependent variable and the explanatory variables under the baseline equation which are capital and labour. The columns labeled Capital1, Capital2, Capital3 and U.S. report the estimated coefficients from PLS estimation. Before commenting on our results, it is important to mention that the null hypothesis of constant returns to scale (the sum of the slope coefficients equal to unity) is rejected in all regressions, with associated p-values below the 1% level of significance.

Table 6 (a) Estimation Results.

	$Y = \beta_1 K + \beta_2 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	−0.04 (0.0970)	0.01 (0.8160)	−0.00 (0.7846)	0.68 (0.0000)
β_2	0.67 (0.0000)	0.64 (0.0000)	0.64 (0.0000)	−0.04 (0.6639)
R^2	0.99	0.99	0.99	0.97
DW	0.26	0.26	0.26	0.14
Specification	Level			
Fixed effects[1]	yes^a	yes^a	yes^a	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^b
Observations	702	702	702	702

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [1]Null hypothesis of no fixed effects, [2]Null hypothesis of no time dummies. ^{a,b}denote significance level at 99.0% and 95.0%, respectively.

Therefore, regarding the case of Capital1 and labour as explanatory variables, it can be observed that some results are surprising. In particular, Capital1 presents a negative and insignificant relationship with output, while there is a positive and statistically significant relationship between labour and output. The results also show that the coefficient on labour is near its elasticity as predicted by the neoclassical framework. However, in contrast to the neoclassical assumptions, the econometric approach finds that the estimated coefficient on Capital1 is statistically insignificant. Hence, our results seem to indicate that capital accumulation might no longer be such a relevant productivity-enhancing factor.

Secondly, with regards to the case of Capital2 and labour as explanatory variables, results are similar to those obtained with Capital1 and labour. There is a positive but highly insignificant relationship between Capital2 and output while there is a positive and highly significant influence of labour to output.

Now turning to the case of Capital3 and labour as explanatory variables, results are quite similar to the previous ones. Scanning down the third column, the slope on Capital3 is statistically insignificant while the slope on labour is statistically significant and presents the expected positive sign. Therefore, more labour would imply an increase in output.

The final column considers the United States case. Contrary to the estimated coefficient on Capital1, Capital2 and Capital3, the estimated coefficient on the United States' capital is highly significant. However, the statistically insignificant coefficient encountered for the labour variable is perhaps somewhat of a concern, it would at the same time indicate that labour is contributing negatively to economic growth..

Table 6 (b) Estimation results.

	$Y = \beta_1 K + \beta_2 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.01 (0.9104)	0.03 (0.4582)	0.02 (0.5502)	0.45 (0.0000)
β_2	0.63 (0.0000)	0.62 (0.0000)	0.62 (0.0000)	0.17 (0.0979)
R^2	0.39	0.39	0.39	0.14
DW	1.83	1.83	1.83	1.70
Specification	First difference			
Fixed effects	no	no	no	no
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [2]Null hypothesis of no time dummies. [a]denotes significance level at 99.0%.

Table 6 (b) repeats these regressions by differentiating the model to eliminate the industry-fixed effects. Effectively, this technique transforms the model by subtracting out industry-fixed means. In this new specification we are not including industry-fixed effects, but we do preserve the time dummies. In short, results indicate that the estimated coefficients on Capital1; Capital2 and Capital3 obtained from the PLS regression are once again unexpected and seem to be statistically insignificant. The slope coefficients of labour in the first three columns of Table (b) resemble of those in Table (a). And all the coefficients are statistically significant. For the United States case, the estimated coefficient on capital is statistically significant at the 5% level of significance. The estimated coefficient on the United States labour is positive but remains statistically insignificant. The null hypothesis of constant returns to scale is rejected in all regressions at the 1% level of significance.

Table 6 (c) Estimation Results.

	$Y = \beta_1 K + \beta_2 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.07 (0.4131)	0.05 (0.3388)	0.05 (0.4178)	0.28 (0.0255)
β_2	0.63 (0.0000)	0.63 (0.0000)	0.63 (0.0000)	0.33 (0.0110)
R^2	0.44	0.44	0.44	0.31
DW	2.01	2.01	2.01	2.12
Specification	First difference			
Fixed effects[1]	yes^b	yes^b	yes^b	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [1]Null hypothesis of no fixed effects, [2]Null hypothesis of no time dummies. ^{a,b}denote significance level at 99.0% and 95.0%, respectively.

In Table 6 (c), we estimated equation (2.6) by first differentiating variables and by allowing fixed effects and time dummies into the model. Once again the slope coefficients on measures of Canadian capital stock are insignificant and the corresponding labour coefficients are highly significant. The estimated coefficients on the United States' capital and labour are significant at the 5% and 1% level of significance respectively.

Table 7 (a) shows the main results when we decompose the capital stock into two components: machinery & equipment and structure. In this specification, machinery & equipment, structure and labour are considered as the explanatory variables. Output is the dependent variable.

Table 7 (a) Estimation Results.

	$Y = \beta_1 M\&E + \beta_2 ST + \beta_3 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.08 (0.0002)	0.10 (0.0000)	0.10 (0.0000)	0.30 (0.0000)
β_2	−0.17 (0.0000)	−0.11 (0.0001)	−0.14 (0.0000)	0.52 (0.0008)
β_3	0.64 (0.0000)	0.61 (0.0000)	0.62 (0.0000)	−0.14 (0.2842)
R^2	0.99	0.99	0.99	0.97
DW	0.26	0.27	0.27	0.14
Specification	Level			
Fixed effects[1]	yes^a	yes^a	yes^a	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^c
Observations	702	702	702	702

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [1]Null hypothesis of no fixed effects, [2]Null hypothesis of no time dummies. ^{a,c}denote significance level at 99.0% and 90.0%, respectively.

The results reported in the first three columns show that machinery & equipment contributes positively to the output, whereas the slope coefficients on the structures are negative and insignificant. The corresponding labour coefficients are highly significant and contribute positively to the output. The final column of Table 7 (a) reports the results for the United States: the estimated coefficients on machinery & equipment, as well as structure, are statistically significant. The estimated labour coefficient shows a negative relationship with output. This particular finding is not consistent with the Cobb-Douglas production function. Moreover, the null hypothesis of constant returns to scale yields a p-value below the 1% level. Consequently, the null hypothesis is rejected.

Table 7(b) Estimation Results.

	$Y = \beta_1 M\&E + \beta_2 ST + \beta_3 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
Variables	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.06 (0.1964)	0.06 (0.0959)	0.06 (0.1342)	0.19 (0.0025)
β_2	−0.12 (0.1565)	−0.06 (0.1961)	−0.07 (0.1961)	0.33 (0.0136)
β_3	0.62 (0.0000)	0.62 (0.0000)	0.62 (0.0000)	0.16 (0.1461)
R^2	0.39	0.39	0.39	0.14
DW	1.84	1.84	1.84	1.71
Specification	First difference			
Fixed effects	no	no	no	no
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [2]Null hypothesis of no time dummies. [a]denotes significance level at 99.0%.

In Table 7 (b), we repeat the same exercises performed in Table 7 (a) by differencing variables to eliminate the industry-fixed effects. In each column, the estimated coefficients on machinery & equipment are positive and marginally significant, but none of the estimated coefficients on structure is statistically significant. Regressions produce very similar results for labour coefficient in the first three columns and the estimated coefficients are highly significant. The estimated coefficient on labour in the fourth column is nevertheless disappointing, but statistically insignificant. Statistical tests reject the null hypothesis of constant returns to scale at the 0.01 level of significance.

Table 7 (c) Estimation Results.

	$Y = \beta_1 M\&E + \beta_2 ST + \beta_3 L + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.05 (0.3529)	0.04 (0.2384)	0.04 (0.3414)	0.11 (0.2138)
β_2	−0.075 (0.5471)	−0.04 (0.5100)	−0.04 (0.5480)	0.22 (0.1234)
β_3	0.63 (0.0000)	0.63 (0.0000)	0.63 (0.0000)	0.34 (0.0107)
R^2	0.44	0.44	0.44	0.31
DW	2.01	2.01	2.01	2.12
Specification	First difference			
Fixed effects[1]	yes^b	yes^b	yes^b	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [1]Null hypothesis of no fixed effects, [2]Null hypothesis of no time dummies. ^{a,b}denote significance level at 99.0% and 90.0%, respectively.

When fixed effects and time dummies are included into the model, Table 7 (c), none of the estimated coefficients on machinery & equipment and the estimated coefficients on structure is significant at the 10% level of significance. But, all the estimated coefficients on labour are statistically significant. Hypothesis test of constant returns to scale is rejected at the 1% level of significant.

Table 8 (a) Estimation Results.

	$\frac{Y}{L} = \beta_1 \frac{K}{L} + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.02 (0.5895)	0.05 (0.0928)	0.05 (0.1329)	0.85 (0.0000)
R^2	0.96	0.96	0.96	0.88
DW	0.24	0.24	0.24	0.13
Specification	Level			
Fixed effects[1]	yes^a	yes^a	yes^a	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^c
Observations	702	702	702	702

*Estimation methods are PLS with (PCSE). P-values are in parentheses. ^{a,c}denote significance level at 99.0% and 90.0%, respectively.

Table 8 (a) reports estimated coefficients of capital-labour ratios, but with output-labour ratios as dependant variables. In this framework, the constant returns to scale assumption is imposed. Results in the first three columns for Canada yield small and insignificant estimated coefficients on capital-labour ratios. The estimated coefficient on capital-labour of the last column is large and highly significant.

Table 8 (b) Estimation Results.

	$\frac{Y}{L} = \beta_1 \frac{K}{L} + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.22 (0.0000)	0.18 (0.0000)	0.20 (0.0000)	0.69 (0.0000)
R^2	0.10	0.10	0.10	0.16
DW	1.82	1.85	1.84	1.67
Specification	First difference			
Fixed effects	no	no	no	no
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [2]Null hypothesis of no time dummies. [a]denotes significance level at 99.0%.

Table 8 (b) shows the estimated coefficients on capital-labour ratios obtained when variables are differentiated and period dummies are allowed into regressions. In this specification, all the estimated coefficients are highly significant.

Table 9 (a) Estimation Results.

	$\frac{Y}{L} = \beta_1 \frac{M\&E}{L} + \beta_2 \frac{ST}{L} + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	-0.02 (0.4226)	0.06 (0.0011)	0.06 (0.0032)	0.29 (0.0000)
β_2	0.06 (0.1720)	-0.02 (0.5627)	-0.01 (0.7133)	0.74 (0.0000)
R^2	0.96	0.96	0.96	0.89
DW	0.24	0.24	0.24	0.14
Specification	Level			
Fixed effects[1]	yes^a	yes^a	yes^a	yes^a
Time dummies[2]	yes^a	yes^a	yes^a	yes^c
Observations	702	702	702	702

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [1]Null hypothesis of no fixed effects, [2]Null hypothesis of no time dummies. ^{a,c}denote significance level at 99.0% and 90.0%, respectively.

The last part of our regressions analysis decomposes the capital-labour ratios into two components: machinery & equipment-labour ratios, and structure-labour ratios.

Table 9 (a) presents the results in which output-labour ratios are taken as the dependent variables and the set of explanatory variables are machinery & equipment-labour ratios and structure-labour ratios. In the first column of Table 9 (a), neither the estimated coefficients on machinery & equipment-labour ratios nor the estimated coefficients on structure-labour ratios are statistically significant. In the second and third columns the estimated coefficients on machinery & equipment-labour ratios are small and statistically significant but the estimated coefficients on structure-labour ratios are statistically insignificant. In the last column of the same table, the estimated coefficients on machinery & equipment-labour ratios as well as structure-labour ratios are statistically significant and present the expected positive sign.

Table 9 (b) Estimation Results.

	$\frac{Y}{L} = \beta_1 \frac{M\&E}{L} + \beta_2 \frac{ST}{L} + \epsilon$			
	Capital1	Capital2	Capital3	U.S.
	Coefficient	Coefficient	Coefficient	Coefficient
β_1	0.02 (0.5978)	0.06 (0.0489)	0.06 (0.0993)	0.19 (0.0025)
β_2	0.24 (0.0007)	0.12 (0.0182)	0.15 (0.0090)	0.57 (0.0001)
R^2	0.11	0.09	0.10	0.17
DW	1.81	1.85	1.84	1.68
Specification	First difference			
Fixed effects	no	no	no	no
Time dummies[2]	yes^a	yes^a	yes^a	yes^a
Observations	663	663	663	663

*Estimation methods are PLS with correction for standard error (PCSE). P-values are in parentheses. [2]Null hypothesis of no time dummies. [a]denotes significance level at 99.0%.

In Table 9 (b) the explanatory variables are the same as those reported in Table 9 (a). But, we first differentiated variables to eliminate industry-fixed effects. All the estimated coefficients on machinery & equipment-labour ratios are statistically significant except that of the first column. The estimated coefficients on structure-labour ratios are positive and statistically significant.

4.3.1 Poolability tests

In order to perform poolability test, we grouped the industries in three groups: manufacturing, primary and services. We estimated separate coefficients for the inputs in the three groups using the model specified in Table 6 (a). We perform Chow test of coefficients equality. Results show evidence of heterogeneity across groups (f-statistic of 10.82, 4.76, 4.37 and 6.31 were respectively reported with Capital 1, 2, 3 and United States' capital as inputs) which are greater than the critical value of 2.56. Consequently, we reject the null hypothesis of coefficients homogeneity and conclude that the panel data are not poolable across groups.

V. Conclusion

This paper has examined empirically the influence of different measures of Canadian capital stock on multifactor productivity growth using panel data from Canada business sector industries for the period 1987-2004. The issue is initially explored by comparing the estimated Canadian multifactor productivity growth with the United States' multifactor productivity data. Using the growth accounting approach.

Our analyses have revealed the picture that emerge from the comparison of the three measures of Canadian capital stock yield substantially different results. When compared to the United States' multifactor productivity growth, the multifactor productivity growth gap between the two countries ranges from 18 to 35 percentage points in the business sector. However, when the high tech industry is excluded from both business sector industries, the gap ranges from 2 to 17 percentage points. Therefore, the great performance in the information and telecommunication technology in the United States during the period of 1987-2004 is behind the widening of the multifactor productivity growth gap between the two countries.

However, even if there is a noticeable difference in terms of growth rates of multifactor productivity computed with the three measures of Canadian capital stock. When these alternative measures are used in various regressions in order to explain the relationship between inputs and outputs, they yield very comparable econometric results in the production function framework. None leads a very satisfactory result. The hypothesis of constant returns to scale is rejected in all specification.

Overall, the findings from this paper suggest that pooling across industries and through time provide limited information on the relationship between inputs and outputs.

References

Abramovitz, Moses. (1956), "Resource and Output Trends in the United States Since 1870," *The American Economic Review* **46,** 5-23.

Armstrong, philip., Tarek M. Harchaoui. Chris Jackson and Faouzi Tarkhani. (2002), "A Comapraison of Canada-U.S. Economic Growth in the Information Age, 1981-2000," *Statistics Canada,* Working Paper **02.**

Barro, Robert J. (1999), "Notes on Growth Accounting," *Journal of Economic Growth* **4,** 119-137.

Beck, Nathaniel., and Jonathan N. Katz (1995), "What to do (and not to do) with Time-Series Cross-Section Data," *The American Political Science Review* **89,** 634-647.

Bernstein, Jeffrey J., Richard G. Harris and Andrew Sharpe.(2002), "The Widening Canada-U.S. Manufacturing Productivity Gap," *International Productivity Monitor* **5,** 3-22.

Bernstein, Jeffrey J. (2000), "Is the Labour Productivity Gap with the United States made in Canada?," *Canadian Business Economics* **8,** 42-49.

Baldwin, John R., and Tarek M. harchaoui (2001), "The Precision of Productivity Measures," *Statistics Canada,* Catalogue no.15-204-XPE, Chap **3,** 39-49.

Baldwin, John R., Tarek M. harchaoui, and Jean-Pierre Maynard. (2001), "Productivity Growth in Canada and the United States," *Statistics Canada,* Catalogue no.15-204-XPE, Chap **4,** 51-60.

Coulombe, Serge. (2002), "The Canada-U.S. Productivity Growth Paradox," *University of Galgary press* Chap **4,** 117-136.

Crawford, Allan. (2002) "Trends in Productivity Growth in Canada," *Bank of Canada Review* **2002,** 19-32.

Griliches, Zvi., and Jacques Mairesse (1995), "Production Functions: The Search For Identification," *National Bureau Of Economic Research*, Working Paper **5067,** 1-41.

Gu, Wulong., and Mun S. Ho. (2000), "A Comparison of Industrial Productivity Growth in Canada and the United States," *The American Economic Review* **90,** 172-175.

Gu, Wulong., Frank C. Lee and Jianmin Tang. (2000), "Economic and Productivity Growth in Canadian Industries," *The American Economic Review* **90,** 168-171.

Jorgenson, Dale W. and Zvi. Griliches. (1967), "The Explanation of Productivity Change," *The Review of Economic Studies* **34,** 249-283.

Jorgenson, Dale W. and Kevin J. Stiroh. (2000), "U.S. Economic Growth at the Industry Level," *The American Economic Review* **90,** 161-167.

Rao, Someshwar., Jianmin Tang and Weimin Wang. (2004), "Measuring the Canada-U.S. Productivity Gap: Industry Dimensions," *International Productivity Monitor* **9,** 3-14.

Rao, Someshwar., Jianmin Tang and Weimin Wang. (2006), "What Explains Canada-U.S. TFP Gap?," *Industry Canada,* Working Paper **06.**

Solow, Robert M. (1956), "A Contribution to the Theory of Economic Growth," *The Quarterly Journal of Economics* **70,** 65-94.

Stiroh, Kevin J. (2002), "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?," *The American Economic Review* **92,** 1559-1576.

Stiroh, Kevin J. (2002), "Are ICT Spillovers Driving the New Economy?," *The Review of Income and Wealth* **48,** 33-57.