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by

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## Abstract

In this paper, we provide a consistent international comparison of the patterns of growth in Canadian and U.S. manufacturing industries over the period 1961-1995. The main findings are as follows: (1) Average annual growth rates of output slowed down dramatically after 1973 in Canadian and U.S. manufacturing, particularly in Canadian manufacturing. (2) During the 1961-1973 period, TFP growth was almost identical in Canadian and U.S. manufacturing. After 1973, growth in manufacturing TFP was slower in Canada than in the United States. (3) The TFP growth gap in Canadian manufacturing for the 1979-1995 period was almost entirely explained by the poor productivity performance of the two high-tech industries in Canada: industrial machinery & equipment, and electronic and electrical equipment. (4) The changes in the composition of the labour force and capital stocks (relatively more educated and older workers, and relatively more equipment compared to structures) contributed to the growth of manufacturing output in both countries.

## 1 Introduction

The purpose of this paper is to provide a consistent international comparison of the patterns of growth of manufacturing industries in Canada and the United States. While much comparative work has been done with respect to sectoral (total factor) productivity[1] in the two countries in the past, this has often been on the basis of concepts that are not entirely comparable. Our approach here is to use methods and definitions that are almost identical for the two countries and therefore to provide a better sense of the relative productivity performance of the two countries.

We find that during the 1961-1973 period, productivity growth was almost identical in Canadian and U.S. aggregate manufacturing. After 1973, however, the growth in productivity of the aggregate manufacturing was slower in Canada than in the United States. A similar finding emerges when we compare the growth in labour productivity between Canadian and U.S. manufacturing, as measured by value added per hour worked – a slightly faster labour productivity growth in Canada before 1973 and slower labour productivity growth in Canada after 1973.

Behind the overall trend in the growth patterns of aggregate manufacturing sector in Canada and the United States, there is substantial variation across individual manufacturing industries. The primary objective of this paper is to characterize the patterns of growth for each of 20 manufacturing industries in the two countries and identify the contribution of each industry to the aggregate manufacturing productivity growth. We find that more than half of the productivity growth in the U.S. manufacturing for the 1979-1995 period comes from the two high-tech manufacturing industries – industrial machinery & equipment, and electronic & electrical equipment. In Canada, the source of growth in aggregate manufacturing productivity is more evenly distributed. The two high-tech manufacturing industries account for only 17 percent of the productivity growth in Canadian manufacturing for the 1979-1995 period.

We have separately analysed the entire business sector in the two countries in Gu and Ho (2000) and find that the relative patterns of productivity growth in this broad sector were quite different from the patterns in manufacturing alone. The Canadian business sector was characterised by a substantial catch-up to U.S. productivity levels during the 1961-1973 period, but then for 1973-95 it saw productivity growth rates only about equal to the U.S. rates and no further closing of the gap. Considering only the manufacturing sector, the Canadian performance was worse. Canada's manufacturing sector was characterised by a rate of productivity growth similar to the United States before 1973 and a rate slower than the U.S. after 1973. Our decomposition results show that the productivity growth gap in Canadian manufacturing after 1979 was mainly due to the relatively poor productivity performance of the two high-tech industries -- industrial machinery & equipment, and electronic & electrical equipment[2]. The slower productivity growth of these two high sectors accounts for about 90 percent of productivity growth gap in Canadian manufacturing for the 1979-1995 period.

Our methodology for international comparisons of growth in output, input, and productivity is based on the economic theory of production. We use measures of labour and capital that take into account the changing composition of the labour force and

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[1] In this study we examine primarily "total factor productivity" as opposed to labour productivity. That is, we consider all inputs – capital, labour, and intermediate goods.

[2] Computer manufacture is in "industrial machinery and equipment" while computer chip making is in "electronic and electrical equipment."

capital stocks (relatively more educated and older workers, and relatively more equipment compared to structures). We show that this rise in the quality[3] of labour and capital inputs contributes to the economic growth of manufacturing sector in both countries.

The paper is organized as follows. In Section 2, we outline the theoretical framework for international comparisons. In Section 3, we present a brief discussion of the data for the measurement of industrial output and input in the two countries. Our empirical findings about the patterns of growth in Canadian and the U.S. manufacturing are summarized in Section 4. Section 5 concludes.

## 2 Methodology

Our methodology for modeling production follows that of Jorgenson, Gollop and Fraumeni (1987) and we will merely summarize that approach here. One may view output as being produced with different types of capital, labour, and intermediate inputs. That is, one may write the production function as:

(1) $$Q_{it} = f(K^i_{1t}, K^i_{2t}, ...K^i_{pt}, L^i_{1t}, L^i_{2t}, ..., L^i_{qt}, X^i_{1t}, X^i_{2t}, ..., X^i_{rt}, t),$$

where $Q_{it}$ is the quantity of output for sector *i* in period *t*; $K^i_{jt}$'s, the various types of capital input (structures, high-tech equipment, low-tech equipment, etc.); and $L^i_{jt}$ and $M^i_{jt}$, the various labour and intermediate inputs. The last argument, *t*, is an index of the level of technology. Such an approach would allow, for example, skilled and unskilled workers to have different elasticities of substitution with different types of capital

[3] The definition of the term "quality" is given in section 2 below.

equipment. However appealing such an approach may be, it is not practicable for a large number of inputs and we assume that the production function can be simplified to:

(2) $Q_{it} = f(K_{it}, L_{it}, M_{it}, t)$

with

(3) $K_{it} = k(K^{i}_{1t}, K^{i}_{2t}, ...K^{i}_{pt})$, $L_{it} = l(L^{i}_{1t}, L^{i}_{2t}, ...L^{i}_{qt})$ and $M_{it} = m(M^{i}_{1t}, M^{i}_{2t}, ...M^{i}_{rt})$.

The requirements for such an aggregation process are well known and we refer the reader to Jorgenson, Gollop and Fraumeni (1987).

We assume that technology is characterized by constant returns to scale and define the cost of capital ($P^{K}_{it}$) in such a way that the value of output is equal to the value of all inputs from the point of view of the producer. This is unlike approaches that do not impose such an equality and calculate the cost of capital by other methods (for example, Hall, 1988). Denoting the price of output to the producer by $P_{it}$ we have:

(4) $P_{it}Q_{it} = P^{K}_{it}K_{it} + P^{L}_{it}L_{it} + P^{M}_{it}M_{it}$,

where $P^{K}_{it}, P^{L}_{it}, P^{M}_{it}$ are the prices of the respective input aggregates. The term for labour, for example, is for total labour compensation paid by producer *i*,

(5) $P^{L}_{it}L_{it} = P^{Li}_{1t}L^{i}_{1t} + P^{Li}_{2t}L^{i}_{2t} + ... + P^{Li}_{qt}L^{i}_{qt}$,

where $P^{L}_{jt}$ is the price of type *j* labour.

We describe the aggregation process (3) in detail below. For the time being, we concentrate on the production constraints described by Equations (2) and (4). To construct an index of productivity for each sector *i*, we assume that the production function (2) may be written in a Hicks-neutral[4] translog form:

$$\ln Q_{it} = a(t) + f(\ln K_{it}, \ln L_{it}, \ln M_{it}).$$

Specifically, the translog index of the rate of productivity growth is given by:

$$(6) \qquad \ln \frac{A_{it}}{A_{it-1}} = \ln \frac{Q_{it}}{Q_{it-1}} - \bar{v}_{it}^{K} \ln \frac{K_{it}}{K_{it-1}} - \bar{v}_{it}^{L} \ln \frac{L_{it}}{L_{it-1}} - \bar{v}_{it}^{M} \ln \frac{M_{it}}{M_{it-1}},$$

where $A_{it}$ is the index of technology in sector *i*, and the weights are input value shares:

$$(7) \qquad \bar{v}_{it}^{K} = \tfrac{1}{2}(v_{it}^{K} + v_{it-1}^{K}); \qquad v_{it}^{K} = \frac{P_{it}^{K} K_{it}}{P_{it} Q_{it}};$$

$$\bar{v}_{it}^{L} = \tfrac{1}{2}(v_{it}^{L} + v_{it-1}^{L}); \qquad v_{it}^{L} = \frac{P_{it}^{L} L_{it}}{P_{it} Q_{it}}; \text{ and}$$

$$\bar{v}_{it}^{M} = \tfrac{1}{2}(v_{it}^{M} + v_{it-1}^{M}); \qquad v_{it}^{M} = \frac{P_{it}^{M} M_{it}}{P_{it} Q_{it}}.$$

The advantages of a chain index like (6) over the fixed-weight indexes are well known and we need not elaborate here. We now turn to the construction of the input aggregates.

In constructing the input aggregates for capital, labour, and intermediates we impose separability assumptions as alluded to in Equations (2) and (3) above. The construction of capital input aggregates is discussed in detail in Gu and Lee (1999) for Canada, and in Ho, Jorgenson and Stiroh (1999) for the United States. The methods for labour input is given in Ho and Jorgenson (1999) for the United States, and in Gu and Maynard (1999) for Canada, and we will merely summarize the main points here.

The capital input index for each sector is constructed in a way that recognizes the tradeoff between detail and tractability. We have chosen to build up from four

[4] For an approach that does not assume Hicks neutrality and estimates productivity growth econometrically,

components – structures, equipment, land, and inventories. Beginning with investment data, we use the perpetual inventory method to derive the various stocks of capital, $A^i_{jt}$. The stock of type *j* created at the end of period *t*-1 produce a flow of capital services $K^i_{jt}$ in period *t*. We assume that the quantity of services is proportional to the stocks:

$$(8) \qquad K^i_{jt} = q^K_j A^i_{jt-1}.$$

Note that the proportionality constant, $q^K_j$, is independent of time, hence the term "constant quality index." These flows of capital services from the various types are then aggregated, using rental costs of capital, $P^{Ki}_{jt}$, that are derived from sectoral value-added data. We express the total flow of capital input into sector *i* as a translog function of the components:

$$(9) \qquad \ln\frac{K_{it}}{K_{it-1}} = \sum_j \tfrac{1}{2}(v^{Ki}_{jt} + v^{Ki}_{jt-1})\ln\frac{K^i_{jt}}{K^i_{jt-1}} = \sum_j \tfrac{1}{2}(v^{Ki}_{jt} + v^{Ki}_{jt-1})\ln\frac{A^i_{jt}}{A^i_{jt-1}},$$

where the weights are value shares of total capital input:

$$(10) \qquad v^{Ki}_{jt} = \frac{P^{Ki}_{jt}K^i_{jt}}{P^K_{it}K_{it}}, \qquad (j = 1,2,..., p),$$

and $P^K_{it}K_{it} = P^{Ki}_{1t}K^i_{1t} + P^{Ki}_{2t}K^i_{2t} + ... + P^{Ki}_{pt}K^i_{pt}$.

In our analysis, we separate the growth of capital input into the effect of capital accumulation and the effect of substitution among the different types of physical assets. The contribution of substitution among components of aggregate capital, which Jorgenson calls the quality index of capital input, is measured as:

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see Chapter 7 of Jorgenson, Gollop and Fraumeni (1987).

(11) $$q_{it}^{K} = \frac{K_{it}}{A_{it-1}},$$

where the total capital stock $A_{it}$ of sector $i$ is defined as the unweighted sum of the individual stocks:

(12) $$A_{it} = \sum_{j} A_{jt}^{i}.$$

Labour input is constructed in a parallel manner. While it might be argued that various categories of labour are not perfect substitutes (e.g., physicists for engineers), that level of detail is clearly not practical and we have chosen to divide the labour force into sex, age, educational attainment, and employment category, as shown in Tables 1 and 2. All workers in a particular category are assumed to earn the same wage and to have the same marginal product. As in Equation (8) above (for capital services), we assume that the flow of effective labour services from group *j* is proportional to the annual number of hours worked by all workers in *j*, $L_{jt}^{i} = q_{j}^{L} H_{jt}^{i}$, where *j* runs over all the cells cross-classified by different categories of workers. For Canada, the total number of cells for each sector is $q = 168$. The total labour input into sector *i* is then the translog aggregate over *j*:

(13) $$\ln \frac{L_{it}}{L_{it-1}} = \sum_{j} \tfrac{1}{2}(v_{jt}^{Li} + v_{jt-1}^{Li}) \ln \frac{L_{jt}^{i}}{L_{jt-1}^{i}} = \sum_{j} \tfrac{1}{2}(v_{jt}^{Li} + v_{jt-1}^{Li}) \ln \frac{H_{jt}^{i}}{H_{jt-1}^{i}},$$

where the weights are the value shares:

$$v_{jt}^{Li} = \frac{P_{jt}^{Li} L_{jt}^{i}}{\sum_{k} P_{kt}^{Li} L_{kt}^{i}}, \quad (j = 1,2,\ldots q).$$

We also wish to decompose the increase in labour input into changes in hours worked and changes in the composition of workers. The measure for the changes in composition, also called quality of labour by Jorgenson, is given as:

(14) $$q_{it}^{L} = \frac{L_{it}}{\sum_{j} H_{jt}^{i}}.$$

Finally, the intermediate input aggregate is defined similarly as a translog aggregate over the various commodities:[5]

(15) $$\ln \frac{M_{it}}{M_{it-1}} = \sum_{j=1}^{r} \tfrac{1}{2}(v_{jt}^{Mi} + v_{jt-1}^{Mi}) \ln \frac{M_{jt}^{i}}{M_{jt-1}^{i}}.$$

## *3 Data*

The starting point for implementing the above methodology is the production account for each industry in both countries (for details, see Jorgenson, Kuroda and Nishimizu, 1987). This includes data on price and quantity indices of output, capital inputs, labour inputs, and intermediate inputs (including energy, materials, and services) for each industry.[6] The value of output in Equation (2) is defined from the point of view of the producer. This includes subsides but excludes all indirect taxes on output as well as trade and transportation margins incurred in the deliveries of output to other sectors.

Similarly, the value of inputs is defined from the producer-purchaser's point of view. The value of labour input includes all taxes levied on labour and all costs incurred in the employment of labour, such as insurance and other fringe benefits. The value of

[5] The data for the intermediate inputs comes from the input-output tables, and we work at the level where $r = 33$ for the U.S.

[6] In this study we use the official data produced by the two governments. There are wide, serious discussions regarding the accuracy of these data, in particular the difficulty in measuring services sector (Triplett, 1998). Our estimates should be read with this in mind.

capital input includes all taxes levied in the ownership and utilization of capital, such as property taxes and corporate income taxes. The value of intermediate input includes all taxes, as well as trade and transportation margins associated with taking deliveries of intermediate inputs from other sectors.

### *3.1 Intermediate Input Data*

For Canada, the industry production account is estimated from the annual input-output (I-O) tables (Durand, 1998, for the transformation of annual input-output tables for productivity analysis). Production accounts were prepared for 122 industries in Canada and 35 industries in the United States. Accounts for these industries are then consolidated into a common set of 33 industries making up the business sector.[7] This paper examines the growth of the 20 manufacturing industries out of these 33 industries.

The industry production account for the United States is an update and modification of that found in Jorgenson, Gollop and Fraumeni (1987). The I-O for 1977-95 come from the U.S. Bureau of Labor Statistics (BLS) and were linked to the pre-1977 tables described in Jorgenson and Wilcoxen (1990).[8]

### *3.2 Labour Input Data*

Price and quantity indices of labour input for each industry in both countries are measured on the basis of labour compensation and hours worked, disaggregated by sex,

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[7] The concordance between the 122 industries of the Canadian business sector and the 33 industries of its U.S. counterpart is presented in Gu and Ho (2000).

[8] The projections of the BLS's Office of Employment provided the time series of the I-O tables as well as industry output and prices at the three-digit level of the Standard Industrial Classification (SIC, 1987 revision). Some of these data are available at ftp://ftp.bls.gov/pub/. These 185 sectors were aggregated to 35 sectors for the U.S. The data in Jorgenson and Wilcoxen (1990) are based on the old SIC classifications and we mapped the two series in 1977. We extrapolated the I-O table to 1996 using the industry output data for that year.

age, educational attainment, and employment category.[9] To ensure the comparability of labour input measures between Canada and the United States, we employed a similar classification scheme for the workforce in the two countries, as shown in Tables 1 and 2. We have seven age groups and four to six educational classes.[10] Due to the different methods of estimating compensation, we also divided workers into employees and self-employed or unpaid family workers,[11] giving a total of 168 cells.

For the United States, the data are derived from decennial Census of the Population, supplemented by the annual Demographic Surveys.[12] The data set consists of the number of workers, their annual weeks worked, their average weekly hours, and their wage rates for each of the cells. Compensation rates for each cell are calculated so that the totals for each industry match those in the National Income Accounts.

For Canada, the data are derived from the Censuses of Population, supplemented by the annual Surveys of Consumer Finance and the monthly Labour Force Surveys. The data set includes hours worked and labour compensation for each type of worker, cross-classified by sex, age, educational attainment, employment class, and industry. The

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[9] Details on the measurement of labour input are found in Gu and Maynard (1999) for Canada, and in Ho and Jorgenson (1999) for the United States.

[10] There is a slight difference in educational attainment categories between Canada and the United States. Because of changes in the definition of educational attainment in the Labour Force Survey in 1990, educational attainment is aggregated into four categories for Canada to ensure consistency over time. For the United States, there are six education categories. This difference in the number of categories is expected to have little effect on our estimates of labour input and labour quality.

[11] Self-employed and unpaid family workers are combined into a single category in the United States. They are treated as two separate categories in Canada. Labour compensation for self-employed workers in Canada was estimated using wage rates for paid workers, while labour compensation for unpaid family workers was ignored. Compensation in the U.S. data is estimated as a residual of non-corporate value-added less a capital income that is calculated to equate rates of return between corporate and non-corporate capital.

[12] The Census provides detailed information (age, education, hours worked, industry worked, wages, etc.) for a 1 percent sample. The U.S. Dept. of Labor conducts annual surveys with similar detail for a smaller sample. These data are used to estimate characteristics of the entire labour force on a time series basis.

estimates of hours worked and labour compensation for each industry are adjusted to the measures of hours worked and compensation produced by Statistics Canada.

### *3.3 Capital Input Data*

To implement Equation (9) for capital input, data on property compensation and capital stocks are required. For both Canada and the United States, industry capital stocks are aggregated from four asset types – non-residential structures, machinery and equipment, land, and inventories.[13] For comparability, the two "structures" categories (building and engineering) in the Canadian data were added to one asset type, while the 56 categories of producer durable equipment in the U.S. data were added to form "machinery and equipment."

The capital stock for the United States was estimated from investment data using geometric depreciation. These U.S. estimates used a 1.65 declining-balance rate for most machinery and equipment, and a 0.9 declining-balance rate for most non-residential structures. The capital stock data published by Statistics Canada applied a modified double-declining-balance method for both machinery and equipment and structures. To ensure comparability between Canadian and U.S. capital stock estimates, we obtained an alternative set of capital stock estimates from the Investment and Capital Stock Division of Statistics Canada. These alternative capital stocks are estimated using the same declining-balance rates as those for the United States (for details, see Koumanakos, Landry, Huang, and Wood, 1999). These estimates will be used in our analysis of patterns of growth in Canadian and U.S. manufacturing industries. However, for a

[13] Details on the measurement of capital inputs are provided in Gu and Lee (1999) for Canada, and in Ho, Jorgenson and Stiroh (1999) for the United States.

comparison, we also present the results using capital stocks that were used in Statistics Canada's productivity estimates.

The cost of capital for each asset is derived from sectoral value-added data using an equation that involves taxes and rates of return. Given the stocks described above, the $P_{jt}^{Ki}$'s in Equation (9) is scaled so that the total value of capital input for sector *i* is equal to the sectoral capital value-added in the National Income Accounts for the U.S. and the KLEMS database in Canada.[14]

## *4 Output Growth and Productivity Growth*

Before we discuss the results we should emphasize that we are comparing growth rates here. The comparison of *absolute* productivity differences between the two countries is given in Lee and Tang (2000). They found that Canadian manufacturing was less productive than U.S. manufacturing in 1995, especially in terms of labour productivity.

### *4.1 Aggregate Manufacturing Sector*

To give an overview of the manufacturing industries, we shall first examine the entire manufacturing sector here and then turn to sectoral estimates in the next section. Table 3 decomposes the growth of output in manufacturing into the contributions of capital quantity and quality, labour quantity and quality, intermediate inputs, and productivity growth for the entire period 1961-1995 and three sub-periods: 1961-1973, 1973-1979, and 1979-1995.

[14] For the U.S. data see "Gross Product by Industry" in *Survey of Current Business*, November 1997.

The output of manufacturing grew faster in Canada than in the United States for the 1961-1973 period -- 5.98 percent per year in Canada vs. 4.69 percent per year in the U.S. After 1973, the growth in manufacturing output slowed down dramatically in both countries, particularly in Canada. Average annual growth rates of output in both countries after 1973 were less than half of their growth rates before 1973. The slowdown in output growth was more pronounced in Canadian manufacturing than in the U.S. manufacturing. By the most recent period 1979-1995, the output growth of manufacturing was similar in the two countries.

Growth in total factor productivity was similar before 1973 in Canadian and U.S. manufacturing (the relative productivity levels are plotted in Figure 1). For the 1961-1973 period, the average annual growth rate of TFP was 1.03 percent in Canadian manufacturing, in comparison to 0.95 percent in the U.S. manufacturing. After 1973, TFP growth of aggregate manufacturing was lower in Canada than in the U.S. For the most recent 1979-1995 period, TFP grew at 0.28 percent per year in Canada -- 0.52 percentage points lower than the 0.80 rate in the U.S.

A similar pattern emerges when we compare the growth of labour productivity between Canadian and U.S. manufacturing, as measured by value added per hour worked – a slightly faster growth rate in Canada before 1973 and a slower rate in Canada after 1973. However, when we measure labour productivity by gross output per hour, the average annual growth rates of labour productivity were almost identical in Canadian and U.S. manufacturing for the 1979-1995 period.

The dominant factors of output growth were increases in capital, labour, and intermediate inputs for both countries, with productivity growth contributing less than a third of the output growth.  For the entire period, in Canada, capital input growth contributed 0.30 percent of the 3.48 percent output growth rate; labour contributed 0.26 percent; intermediate inputs, 2.37; and productivity growth, 0.55 percent.  The 0.30 percent capital contribution can be decomposed into 0.22 percent for capital accumulation and 0.08 percent for quality change.  Similarly, the 0.26 percent labour contribution is made up of 0.19 percent for increased hours worked and 0.07 percent for quality change.  In the United States, of the 2.79 percent output growth rate, capital, labour, intermediate input and productivity contributions were 0.30, 0.23, 1.39, and 0.86 percent, respectively.  One can see that quality changes in capital are roughly similar in the two countries, while labour quality growth in the United States is higher.

### *4.2 A Comparison across 20 Manufacturing Industries*

The description above of growth in aggregate manufacturing masks a wide variation in growth among industries.  In this section, we turn to the performance of individual industries for three sub-periods: 1961-1973, 1973-1979, and 1979-1995. Table 4 presents the average annual growth rates of output, inputs and TFP in Canadian and U.S. manufacturing industries during the 1961-1973 period.  We also provide estimates of labour productivity, as defined as gross output per hour worked.  Over that period average growth rates of output were higher in Canada in 18 of 20 industries, in particular motor vehicles.  The TFP of aggregate manufacturing in Canada grew at a rate similar to the U.S.  But there was wide variation in TFP growth among industries.  For the 1961-1973 period, 14 of 20 manufacturing industries had faster TFP growth in Canada than the United States, including most notably, motor vehicles.

In the next two tables (Tables 5 and 6), we present the average annual growth rates of output, inputs, and productivity in the sub-periods 1973-1979 and 1979-1995. The growth in output of manufacturing slowed dramatically after 1973 in both countries, particularly in Canada. The growth of TFP in aggregate manufacturing was slower in Canada than in the United States for the 1973-1979 and 1979-1995 periods. For the 1979-1995 period, TFP grew at annual rates of 0.28 and 0.80 percent in Canadian and U.S. manufacturing, which represents a 0.52 percent TFP growth gap for Canadian manufacturing. During that period, 14 of the 20 Canadian manufacturing industries had slower TFP growth than the U.S., particularly the two high-tech manufacturing industries: industrial machinery & equipment, and electronic and electrical equipment.

An important development in Canadian and U.S. manufacturing growth since the early 1980s has been the rapid growth of output in the two high-tech industries: industrial machinery & equipment industry producing computers; and electronic & electrical equipment industry producing semi-conductors.[15] These two industries also show rapid TFP growth in the United States, but not in Canada. In the United States, these two high-tech industries had the two highest average annual growth rates of TFP and output among manufacturing industries for the 1979-1995 period. In Canada, these two high-tech industries also had the 2$^{nd}$ and 3$^{rd}$ highest output growth rates among manufacturing industries, just behind motor vehicles. But their TFP growth rates in Canada were anything but spectacular -- a meagre 0.56 percent for industrial machinery and equipment and 0.57 percent for electronic and electrical equipment. The contribution of the two high-tech industries to the aggregate manufacturing productivity growth gap in

[15] Computer chip manufacturers are almost non-existent in Canada.

the two countries over the 1979-1995 period is a subject of the analysis in the next section.

Tables 1, 2, and 3 in the appendix present the average annual growth rates of capital input and quality, labour input and quality, and intermediate inputs separately. In comparison to the U.S. manufacturing, the growth of capital and labour inputs in Canadian manufacturing was faster before 1973. After 1973, capital input of Canadian manufacturing grew slower and labour input grew at a rate similar to the U.S. manufacturing. Compositional changes in capital stocks toward Machinery & Equipment had led to increases in capital quality in most industries for both countries, except for the 1973-1979 period in Canada. Labour quality also increased for almost all industries for the 1961-1973 and 1979-1995 periods in the two countries, primarily due to increases in the educational attainment of the workforce. For the 1973-1979 period, labour quality declined in many industries as baby boomers and less-experienced young workers entered the workforce in the two countries.

An interesting feature of Canadian manufacturing growth has been the high growth of intermediate inputs. In fact, for the 1961-1973 and 1973-1979 periods, the average annual growth rates of intermediate inputs were higher in Canada than in the U.S. for almost all manufacturing industries, 19 of 20 industries during the 1961-1973 period and 18 during the 1973-1979 period. Most significantly, after 1973 intermediate input grew faster than gross output in Canadian manufacturing, while it grew slower than gross output in the U.S. manufacturing. As a result, intermediate goods intensity increased in Canadian manufacturing, and it declined in the U.S. manufacturing. This may suggest that the vertical disintegration of production and outsourcing have been proceeding at a faster pace in Canadian manufacturing. Our data also show that the share of intermediate input in gross output was higher in Canadian manufacturing throughout the period, probably indicative of a high degree of vertical disintegration in Canadian manufacturing.

### *4.3 An Industry Decomposition of Aggregate Manufacturing Productivity*

To identify the sources of aggregate TFP growth and the TFP growth gap between Canadian and U.S. manufacturing for the 1979-1995 period, we decompose the TFP growth in into the contributions of each industry. We have constructed aggregate TFP growth of manufacturing as a weighted average of industry productivity growth rates (Ezaki and Jorgenson 1973). The weights are equal to the average shares of industry gross output in total manufacturing gross output over the period. The contribution of each industry to aggregate TFP growth is measured as the industry productivity growth rate multiplied by the average share of the industry gross output.

Table 7 presents the industry decomposition results for TFP growth of Canadian and U.S. total manufacturing for the 1979-1995 period. The sum of industry contributions to aggregate TFP growth is 0.36 percent for Canada and 0.77 percent for the United States. When we can compare this estimate of the TFP growth with the TFP growth estimated from an aggregate production function for total manufacturing as shown in Table 3, we find that the two estimates are almost identical. The slight difference in these estimates arises from the reallocations of inputs and outputs across industries.

There is a large variation in contributions to aggregate manufacturing TFP growth across industries. For example, motor vehicles in Canada had TFP growth of 0.54

percent contributing 0.08 percentage points to manufacturing TFP for the 1979-1995 period. By contrast, printing in Canada had negative TFP growth of 0.97 percent and reduced manufacturing TFP growth by 0.04 percent.

The gains in U.S. manufacturing productivity were highly concentrated in the two high-tech industries while the gains in Canadian manufacturing were widely dispersed. In the United States, the two high-tech industries account for about 60 percent of TFP growth in total manufacturing for the 1979-1995 period. In Canada, they only account for 17 percent of manufacturing TFP growth. These two industries had the highest TFP growth rates among the U.S. manufacturing industries, nearly 3 percent per year. In Canada, the TFP growth of the two industries was significantly slower. The TFP of the two high-tech industries in Canada grew at only 0.6 percent per year, outperformed by such Canadian industries as lumber & wood, chemicals, and fabricated metals.

Our industry decomposition also allows us to examine the underlying sources of TFP growth gap between Canadian and U.S. manufacturing since the early 1980s. Andrew Sharpe (1999) has recently argued that the TFP growth gap for Canadian manufacturing was entirely explained by the poor productivity performance of the two high-tech industries in Canada. Our result in Table 8 confirms the Sharpe's finding. The slow TFP growth of the two high-tech industries in Canada account for 90% of the TFP growth gap for Canadian manufacturing for the 1979-1995 period. On the other hand, the motor vehicles and lumber & wood made significant contributions to closing the TFP growth gap.

## 5 Conclusion

In this paper, we applied a similar methodology to provide a consistent international comparison of the patterns of growth in Canadian and U.S. manufacturing industries over the period 1961-1995. The main findings are as follows: (1) Average annual growth rates of output slowed down dramatically after 1973 in Canadian and U.S. manufacturing, particularly in Canadian manufacturing. The growth rates of manufacturing output after 1973 was less than half of the rates before 1973 for both countries. (2) During the 1961-1973 period, TFP growth was almost identical in Canadian and U.S. manufacturing. After 1973, growth in manufacturing TFP was slower in Canada than in the United States. (3) The gains in U.S. manufacturing productivity after 1979 were highly concentrated in the two high-tech industries while the gains in Canadian manufacturing were widely dispersed. (4) The TFP growth gap in Canadian manufacturing for the 1979-1995 period was almost entirely explained by the poor productivity performance of the two high-tech industries in Canada: industrial machinery & equipment, and electronic and electrical equipment. (5) An interesting feature of Canadian manufacturing growth has been the high growth of intermediate inputs, indicating that the vertical disintegration of production and outsourcing have been proceeding at a faster pace in Canadian manufacturing. (6) The rise in capital and labour quality caused by composition changes plays a role in the manufacturing growth of both countries.

Since the early 1980s, a key development in manufacturing growth has been the emergence of large productivity growth gap for the two high-tech industries in Canada. Understanding the sources of this productivity growth gap presents a challenge for researchers. Sharpe (1999) suggests that the TFP growth gap of the two high-tech sectors in Canada can be partially explained by the difference in the hedonic price adjustments for the two sectors' output (computers and semi-conductors) in the two countries. In a recent paper, Trajtenberg (1999) finds that Canada is granted relatively fewer patents in key growth sectors such as computer hardware and software in comparison to the United States. Drawing on the findings by Trajtenberg, Trefler (1999) argues that the TFP growth gap of the Canadian high-tech sectors is real and it represents a gap in product innovation in Canadian manufacturing.

## *6 Appendix: Sources of Output Growth Based on the Capital Stock Data in Statistics Canada's KLEMS Database*

Statistics Canada's estimates of productivity growth are based on capital stock data, using a modified double-declining-balance method. For comparison purposes, Table 4 in the appendix presents the sources of output growth for Canadian manufacturing, using these capital stock data. Comparing Table 4 in the appendix and Table 3 in the main text, we find that the contributions of capital input were slightly lower than those based on capital stock estimates that are comparable to the BLS estimates. As a result, productivity growth estimates were higher, using the capital stock estimates based on a modified double-declining-balance method. There is a gradual increase in the differences between these two productivity growth estimates, from 0.02 percent for 1961-1973 to 0.08 percent for 1973-1979 and 0.09 percent in 1979-1995.

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**Table 1**
**Classification of the Canadian Workforce**

| Worker Characteristics | Number of Categories | Type |
|---|---|---|
| Sex | 2 | Female; Male |
| Employment category | 3 | Paid employees; self-employed; unpaid family workers |
| Age | 7 | 15-17; 18-24; 25-34; 35-44; 45-54; 55-64; 65+ |
| Education | 4 | 0-8 years grade school; some or completed high school; some or completed post-secondary; university or above |

**Table 2**
**Classification of the U.S. Workforce**

| Worker Characteristics | Number of Categories | Type |
|---|---|---|
| Sex | 2 | Female; male |
| Employment category | 2 | Paid employees; self-employed and unpaid family workers |
| Age | 7 | 16-17; 18-24; 25-34; 35-44; 45-54; 55-64; 65+ |
| Education | 6 | 0-8 years grade school; 1-3 years high school; 4 years high school; 1-3 years college; 4 years college; 5+ years college |

**Table 3**
**Sources of Output Growth in Manufacturing in Canada and the United States**
**(average % growth per year)**

| | *Canada* | | | |
|---|---|---|---|---|
| | 1961-1995 | 1961-1973 | 1973-1979 | 1979-1995 |
| Gross Output | 3.48 | 5.98 | 2.52 | 1.97 |
| Contribution of Capital Stock | 0.22 | 0.33 | 0.21 | 0.14 |
| Contribution of Capital Quality | 0.08 | 0.18 | 0.03 | 0.02 |
| Contribution of Hours Worked | 0.19 | 0.58 | 0.13 | -0.08 |
| Contribution of Labor Quality | 0.07 | 0.08 | 0.02 | 0.08 |
| Contribution of Intermediate Inputs | 2.37 | 3.78 | 1.83 | 1.52 |
| TFP Growth | 0.55 | 1.03 | 0.30 | 0.28 |
| LP Growth, based on Value Added | 2.55 | 3.97 | 1.61 | 1.83 |
| LP Growth, based on Gross Output | 2.75 | 3.77 | 1.95 | 2.28 |

| | *The United States* | | | |
|---|---|---|---|---|
| | 1961-1995 | 1961-1973 | 1973-1979 | 1979-1995 |
| Gross Output | 2.79 | 4.69 | 1.81 | 1.73 |
| Contribution of Capital Stock | 0.24 | 0.31 | 0.29 | 0.17 |
| Contribution of Capital Quality | 0.06 | 0.10 | 0.06 | 0.02 |
| Contribution of Hours Worked | 0.10 | 0.42 | 0.18 | -0.16 |
| Contribution of Labor Quality | 0.13 | 0.10 | 0.07 | 0.17 |
| Contribution of Intermediate Inputs | 1.39 | 2.80 | 0.36 | 0.73 |
| TFP Growth | 0.86 | 0.95 | 0.85 | 0.80 |
| LP Growth, based on Value Added | 3.17 | 3.46 | 3.03 | 3.00 |
| LP Growth, based on Gross Output | 2.37 | 3.02 | 1.23 | 2.32 |

**Table 4. Average Annual Growth Rates of Output, Inputs, and Productivity In Canada and the United States, 1961-1973**

| | Canada | | | | The United States | | | |
|---|---|---|---|---|---|---|---|---|
| | Output | Inputs | TFP | LP* | Output | Inputs | TFP | LP* |
| 1. Food | 3.39 | 2.83 | 0.56 | 2.83 | 2.63 | 2.12 | 0.51 | 1.76 |
| 2. Tobacco | 2.18 | 1.50 | 0.68 | 3.62 | 0.85 | -0.56 | 1.41 | 1.50 |
| 3. Textile | 6.04 | 4.48 | 1.56 | 4.94 | 3.88 | 3.15 | 0.74 | 3.97 |
| 4. Apparel | 4.82 | 3.89 | 0.92 | 3.83 | 4.22 | 3.53 | 0.69 | 2.39 |
| 5. Lumber & wood | 4.87 | 4.09 | 0.77 | 3.86 | 4.64 | 4.79 | -0.15 | 3.52 |
| 6. Furniture | 6.88 | 5.14 | 1.74 | 3.75 | 5.41 | 4.85 | 0.55 | 2.65 |
| 7. Paper | 4.68 | 4.49 | 0.19 | 2.80 | 4.68 | 3.67 | 1.00 | 3.91 |
| 8. Printing | 3.86 | 3.38 | 0.49 | 2.00 | 3.26 | 2.67 | 0.60 | 2.79 |
| 9. Chemicals | 6.37 | 4.94 | 1.43 | 4.40 | 6.54 | 4.91 | 1.64 | 4.90 |
| 10. Petroleum refining | 6.18 | 5.57 | 0.62 | 4.69 | 3.63 | 2.44 | 1.19 | 4.17 |
| 11. Rubber & plastics | 10.10 | 7.96 | 2.13 | 4.47 | 8.59 | 6.83 | 1.76 | 3.84 |
| 12. Leather | 0.88 | 0.26 | 0.62 | 2.59 | -0.51 | -0.10 | -0.42 | 1.44 |
| 13. Stone, clay & glass | 6.10 | 4.27 | 1.83 | 3.84 | 3.80 | 3.08 | 0.72 | 2.90 |
| 14. Primary metals | 5.18 | 4.50 | 0.68 | 2.74 | 4.15 | 3.73 | 0.42 | 3.60 |
| 15. Fabricated metals | 6.80 | 5.60 | 1.20 | 3.16 | 4.90 | 3.95 | 0.95 | 2.85 |
| 16. Industrial machinery | 7.87 | 6.37 | 1.50 | 4.08 | 6.14 | 5.57 | 0.56 | 2.41 |
| 17. Electronic equipment | 7.26 | 5.22 | 2.05 | 4.04 | 6.88 | 5.30 | 1.58 | 3.90 |
| 18. Motor vehicles | 13.69 | 11.15 | 2.54 | 5.32 | 6.55 | 6.05 | 0.50 | 3.12 |
| 19. Other trans. equip. | 4.23 | 3.77 | 0.46 | 2.84 | 2.75 | 2.29 | 0.46 | 1.85 |
| 20. Misc. manufacturing | 5.95 | 4.59 | 1.36 | 3.49 | 5.34 | 3.79 | 1.55 | 3.32 |
| Total Manufacturing | 5.98 | 4.95 | 1.03 | 3.77 | 4.69 | 3.74 | 0.95 | 3.02 |

* LP is labour productivity, defined as gross output per hour worked.

**Table 5. Average Annual Growth Rates of Output, Inputs, and Productivity In Canada and the United States, 1973-1979**

| | Canada | | | | The United States | | | |
|---|---|---|---|---|---|---|---|---|
| | Output | Inputs | TFP | LP* | Output | Inputs | TFP | LP* |
| 1. Food | 2.15 | 2.02 | 0.13 | 1.65 | 2.13 | 1.80 | 0.33 | 0.01 |
| 2. Tobacco | 1.60 | 1.38 | 0.21 | 3.21 | -0.21 | 1.14 | -1.36 | -1.39 |
| 3. Textile | 2.08 | 0.06 | 2.02 | 4.69 | 2.19 | -0.77 | 2.96 | -2.40 |
| 4. Apparel | 2.40 | 0.33 | 2.07 | 4.03 | -0.21 | -2.11 | 1.90 | -0.53 |
| 5. Lumber & wood | 2.30 | 2.25 | 0.06 | 1.31 | 0.86 | 0.77 | 0.08 | -1.11 |
| 6. Furniture | 0.01 | 0.39 | -0.38 | -0.34 | 0.77 | 0.21 | 0.56 | -3.25 |
| 7. Paper | 1.58 | 1.84 | -0.27 | 1.35 | 1.71 | 2.44 | -0.73 | -0.20 |
| 8. Printing | 4.24 | 2.56 | 1.67 | 2.81 | 2.13 | 3.23 | -1.10 | -4.79 |
| 9. Chemicals | 5.52 | 5.77 | -0.25 | 3.59 | 3.02 | 5.88 | -2.86 | -4.05 |
| 10. Petroleum refining | 2.82 | 3.35 | -0.53 | 0.99 | 4.82 | 5.18 | -0.36 | 7.31 |
| 11. Rubber & plastics | 4.72 | 4.02 | 0.70 | 2.03 | 0.85 | 1.85 | -1.00 | -3.96 |
| 12. Leather | 2.15 | 0.55 | 1.60 | 3.10 | -2.73 | -2.72 | -0.01 | -2.39 |
| 13. Stone, clay & glass | 1.66 | 1.99 | -0.34 | 2.08 | 0.77 | 1.56 | -0.79 | -1.88 |
| 14. Primary metals | 1.48 | 1.08 | 0.40 | 0.55 | -1.12 | -0.14 | -0.99 | -4.36 |
| 15. Fabricated metals | 2.01 | 2.39 | -0.37 | 0.69 | 0.67 | 1.23 | -0.56 | -3.10 |
| 16. Industrial machinery | 5.28 | 4.03 | 1.25 | 2.00 | 2.52 | 3.18 | -0.67 | -3.30 |
| 17. Electronic equipment | 1.25 | -0.19 | 1.43 | 2.78 | 2.09 | 1.03 | 1.05 | -1.16 |
| 18. Motor vehicles | 2.56 | 1.79 | 0.77 | 2.54 | 1.11 | 0.89 | 0.22 | 1.24 |
| 19. Other trans. Equip. | 3.77 | 3.55 | 0.22 | 0.86 | 3.06 | 4.03 | -0.98 | -4.29 |
| 20. Misc. manufacturing | 2.09 | 1.23 | 0.86 | 1.44 | 3.71 | 4.76 | -1.06 | -3.76 |
| Total Manufacturing | 2.52 | 2.22 | 0.30 | 1.95 | 1.81 | 0.96 | 0.85 | 1.23 |

* LP is labour productivity, defined as gross output per hour worked.

**Table 6. Average Annual Growth Rates of Output, Inputs, and Productivity In Canada and the United States, 1979-1995**

| | Canada | | | | The United States | | | |
|---|---|---|---|---|---|---|---|---|
| | Output | Inputs | TFP | LP* | Output | Inputs | TFP | LP* |
| 1. Food | 1.00 | 1.04 | -0.04 | 1.62 | 1.84 | 1.06 | 0.78 | 2.11 |
| 2. Tobacco | -1.92 | -2.43 | 0.51 | 2.34 | -0.45 | 0.54 | -0.99 | 0.42 |
| 3. Textile | 0.20 | -0.43 | 0.63 | 1.90 | 1.09 | 0.22 | 0.88 | 2.21 |
| 4. Apparel | -0.35 | -0.76 | 0.42 | 1.79 | 1.29 | 0.72 | 0.57 | 2.30 |
| 5. Lumber & wood | 2.62 | 1.90 | 0.71 | 3.04 | 1.30 | 1.46 | -0.16 | 1.08 |
| 6. Furniture | 1.59 | 1.48 | 0.11 | 1.29 | 2.20 | 1.82 | 0.38 | 2.20 |
| 7. Paper | 1.78 | 1.75 | 0.03 | 2.66 | 1.73 | 1.83 | -0.11 | 1.00 |
| 8. Printing | 0.98 | 1.95 | -0.97 | -0.29 | 1.98 | 3.05 | -1.07 | -0.82 |
| 9. Chemicals | 2.32 | 1.19 | 1.13 | 2.40 | 1.02 | 0.18 | 0.84 | 1.94 |
| 10. Petroleum refining | -0.59 | -1.00 | 0.41 | 1.83 | 0.12 | -0.90 | 1.01 | 0.77 |
| 11. Rubber & plastics | 3.37 | 2.81 | 0.56 | 1.66 | 3.98 | 3.12 | 0.86 | 1.93 |
| 12. Leather | -4.07 | -4.25 | 0.18 | 0.94 | -3.11 | -4.03 | 0.92 | 3.98 |
| 13. Stone, clay & glass | -0.91 | -0.80 | -0.10 | 0.59 | 0.23 | -0.28 | 0.51 | 1.07 |
| 14. Primary metals | 1.23 | 0.96 | 0.27 | 3.34 | -1.13 | -1.42 | 0.30 | 1.63 |
| 15. Fabricated metals | 0.23 | -0.47 | 0.70 | 1.06 | 0.77 | 0.02 | 0.75 | 2.58 |
| 16. Industrial machinery | 4.48 | 3.92 | 0.56 | 3.58 | 4.63 | 1.69 | 2.94 | 6.06 |
| 17. Electronic equipment | 3.75 | 3.18 | 0.57 | 4.58 | 4.90 | 2.19 | 2.71 | 6.55 |
| 18. Motor vehicles | 5.09 | 4.55 | 0.54 | 3.18 | 2.09 | 2.22 | -0.13 | 1.47 |
| 19. Other trans. Equip. | 2.17 | 1.76 | 0.41 | 2.54 | -0.19 | -0.38 | 0.19 | 1.88 |
| 20. Misc. manufacturing | 1.26 | 1.21 | 0.05 | 0.73 | 2.27 | 1.67 | 0.59 | 2.17 |
| Total Manufacturing | 1.97 | 1.69 | 0.28 | 2.28 | 1.73 | 0.93 | 0.80 | 2.32 |

* LP is labour productivity, defined as gross output per hour worked.

**Table 7. An Industry Decomposition of Aggregate Manufacturing Productivity Growth In Canada and the United States, 1979-1995**

| | Canada | | | The United States | | |
|---|---|---|---|---|---|---|
| | Weights* | TFP Growth | Agg. TFP Contribution | Weights* | TFP Growth | Agg. TFP Contribution |
| 1. Food | 0.147 | -0.040 | -0.006 | 0.120 | 0.780 | 0.093 |
| 2. Tobacco | 0.009 | 0.512 | 0.004 | 0.013 | -0.988 | -0.013 |
| 3. Textile | 0.018 | 0.626 | 0.012 | 0.018 | 0.877 | 0.016 |
| 4. Apparel | 0.023 | 0.418 | 0.010 | 0.031 | 0.572 | 0.018 |
| 5. Lumber & wood | 0.074 | 0.714 | 0.053 | 0.028 | -0.164 | -0.005 |
| 6. Furniture | 0.013 | 0.111 | 0.001 | 0.014 | 0.380 | 0.005 |
| 7. Paper | 0.067 | 0.027 | 0.002 | 0.042 | -0.107 | -0.004 |
| 8. Printing | 0.037 | -0.972 | -0.036 | 0.050 | -1.068 | -0.053 |
| 9. Chemicals | 0.068 | 1.129 | 0.077 | 0.100 | 0.835 | 0.083 |
| 10. Petroleum refining | 0.060 | 0.409 | 0.024 | 0.055 | 1.014 | 0.055 |
| 11. Rubber & plastics | 0.028 | 0.559 | 0.015 | 0.034 | 0.857 | 0.029 |
| 12. Leather | 0.004 | 0.182 | 0.001 | 0.004 | 0.924 | 0.003 |
| 13. Stone, clay & glass | 0.024 | -0.102 | -0.002 | 0.023 | 0.514 | 0.012 |
| 14. Primary metals | 0.072 | 0.273 | 0.020 | 0.063 | 0.296 | 0.019 |
| 15. Fabricated metals | 0.049 | 0.699 | 0.034 | 0.061 | 0.747 | 0.046 |
| 16. Industrial machinery | 0.060 | 0.555 | 0.033 | 0.086 | 2.944 | 0.254 |
| 17. Electronic equipment | 0.048 | 0.569 | 0.027 | 0.070 | 2.708 | 0.189 |
| 18. Motor vehicles | 0.148 | 0.539 | 0.080 | 0.093 | -0.130 | -0.012 |
| 19. Other trans. Equip. | 0.029 | 0.413 | 0.012 | 0.045 | 0.188 | 0.008 |
| 20. Misc. manufacturing | 0.022 | 0.052 | 0.001 | 0.050 | 0.594 | 0.030 |
| Total Manufacturing | | | 0.362 | | | 0.773 |

* The weight is the average share of industry gross output in total manufacturing.

**Table 8. Industrial Contribution to the Aggregate Productivity Growth Gap between Canadian and the U.S. Manufacturing, 1979-1995**

| | Agg. TFP Contribution in Canada | Agg. TFP Contribution in the U.S. | Contribution to Agg. TFP Growth Gap (%) |
|---|---|---|---|
| 1. Food | -0.006 | 0.093 | 24.09 |
| 2. Tobacco | 0.004 | -0.013 | -4.14 |
| 3. Textile | 0.012 | 0.016 | 0.97 |
| 4. Apparel | 0.010 | 0.018 | 1.95 |
| 5. Lumber & wood | 0.053 | -0.005 | -14.11 |
| 6. Furniture | 0.001 | 0.005 | 0.97 |
| 7. Paper | 0.002 | -0.004 | -1.46 |
| 8. Printing | -0.036 | -0.053 | -4.14 |
| 9. Chemicals | 0.077 | 0.083 | 1.46 |
| 10. Petroleum refining | 0.024 | 0.055 | 7.54 |
| 11. Rubber & plastics | 0.015 | 0.029 | 3.41 |
| 12. Leather | 0.001 | 0.003 | 0.49 |
| 13. Stone, clay & glass | -0.002 | 0.012 | 3.41 |
| 14. Primary metals | 0.020 | 0.019 | -0.24 |
| 15. Fabricated metals | 0.034 | 0.046 | 2.92 |
| 16. Industrial machinery | 0.033 | 0.254 | 53.77 |
| 17. Electronic equipment | 0.027 | 0.189 | 39.42 |
| 18. Motor vehicles | 0.080 | -0.012 | -22.38 |
| 19. Other trans. Equip. | 0.012 | 0.008 | -0.97 |
| 20. Misc. manufacturing | 0.001 | 0.030 | 7.06 |
| Total Manufacturing | 0.362 | 0.773 | 100 |

## Appendix Table 1. Average Annual Growth Rates of Inputs in Canada and the United States, 1961-1973

| | Canada | | | | | The United States | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | K Input | K Qual. | L Input | L Qual. | U | K Input | K Qual. | L Input | L Qual. | U |
| 1. Food | 4.07 | 0.57 | 0.81 | 0.25 | 3.13 | 4.20 | 0.88 | 1.16 | 0.30 | 2.16 |
| 2. Tobacco | 2.28 | 0.48 | -0.63 | 0.80 | 1.76 | 0.03 | 0.15 | 0.24 | 0.90 | -0.82 |
| 3. Textile | 4.20 | 0.49 | 1.43 | 0.33 | 5.86 | 3.29 | 1.58 | 0.22 | 0.30 | 3.89 |
| 4. Apparel | 3.93 | 0.77 | 1.00 | 0.01 | 5.42 | 8.21 | 0.95 | 2.30 | 0.47 | 3.76 |
| 5. Lumber & wood | 4.82 | 0.98 | 1.51 | 0.50 | 5.68 | 2.86 | 0.44 | 1.85 | 0.72 | 6.25 |
| 6. Furniture | 4.03 | 0.31 | 3.33 | 0.20 | 6.43 | 7.63 | 1.38 | 3.49 | 0.73 | 5.29 |
| 7. Paper | 5.93 | 0.44 | 2.11 | 0.24 | 5.25 | 4.24 | 0.81 | 1.16 | 0.39 | 4.63 |
| 8. Printing | 3.39 | 0.11 | 2.04 | 0.18 | 4.66 | 4.57 | 0.36 | 0.50 | 0.03 | 3.81 |
| 9. Chemicals | 5.34 | 0.89 | 2.22 | 0.25 | 5.86 | 6.69 | 0.93 | 1.80 | 0.15 | 5.57 |
| 10. Petroleum refining | 3.92 | 6.16 | 1.80 | 0.31 | 6.03 | 3.29 | 1.25 | -0.15 | 0.39 | 2.74 |
| 11. Rubber & plastics | 6.15 | 0.64 | 5.65 | 0.02 | 9.50 | 6.36 | 0.35 | 5.07 | 0.33 | 7.85 |
| 12. Leather | 2.45 | 1.07 | -1.79 | -0.08 | 1.31 | 1.09 | 0.95 | -0.97 | 0.99 | 0.26 |
| 13. Stone, clay & glass | 3.63 | 0.50 | 2.60 | 0.35 | 5.46 | 2.87 | 1.16 | 1.53 | 0.63 | 4.26 |
| 14. Primary metals | 4.58 | 0.85 | 2.72 | 0.28 | 5.07 | 2.75 | 1.38 | 0.89 | 0.34 | 4.73 |
| 15. Fabricated metals | 4.38 | 0.98 | 3.92 | 0.29 | 6.78 | 5.17 | 0.80 | 2.16 | 0.11 | 4.82 |
| 16. Industrial machinery | 3.87 | 0.51 | 4.13 | 0.34 | 8.47 | 5.69 | 0.59 | 3.95 | 0.23 | 6.57 |
| 17. Electronic equipment | 4.47 | 0.55 | 3.37 | 0.15 | 6.51 | 9.99 | 1.77 | 3.19 | 0.20 | 5.70 |
| 18. Motor vehicles | 5.00 | 1.01 | 8.56 | 0.19 | 12.71 | 5.21 | 1.18 | 3.75 | 0.31 | 6.88 |
| 19. Other trans. equip. | 1.85 | -0.52 | 1.80 | 0.41 | 5.42 | 6.06 | 0.56 | 1.26 | 0.36 | 2.68 |
| 20. Misc. manufacturing | 6.21 | 0.26 | 2.67 | 0.20 | 5.52 | 5.43 | 0.36 | 2.52 | 0.50 | 4.41 |
| Total Manufacturing | 4.42 | 1.51 | 2.52 | 0.31 | 5.92 | 4.04 | 1.00 | 2.04 | 0.37 | 4.41 |

## Appendix Table 2. Average Annual Growth Rates of Inputs in Canada and the United States, 1973-1979

| | Canada | | | | | The United States | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | K Input | K Qual. | L Input | L Qual. | U | K Input | K Qual. | L Input | L Qual. | U |
| 1. Food | 1.20 | 0.06 | 0.49 | 0.06 | 2.07 | 4.81 | 0.55 | 1.87 | 0.05 | 1.14 |
| 2. Tobacco | 1.17 | 0.11 | -0.61 | 0.78 | 1.58 | 5.47 | 0.08 | 1.20 | 0.19 | -0.72 |
| 3. Textile | -0.71 | -0.49 | -2.07 | 0.17 | 1.06 | 7.29 | 0.31 | 3.81 | -0.12 | -2.58 |
| 4. Apparel | 1.11 | -0.73 | -1.35 | 0.05 | 1.09 | 3.72 | -0.05 | 0.17 | -0.10 | -3.31 |
| 5. Lumber & wood | 3.46 | 0.35 | 1.03 | 0.19 | 2.21 | 5.40 | 0.20 | 1.32 | -0.37 | -0.24 |
| 6. Furniture | -0.48 | -0.41 | 0.37 | 0.08 | 0.43 | 7.10 | 0.25 | 2.71 | -0.74 | -2.26 |
| 7. Paper | 0.70 | -0.21 | 0.37 | 0.18 | 2.21 | 5.96 | 0.63 | 1.97 | 0.34 | 1.42 |
| 8. Printing | 1.76 | -0.05 | 1.00 | -0.22 | 3.36 | 4.81 | 0.33 | 6.95 | 1.01 | -0.85 |
| 9. Chemicals | 6.41 | 0.31 | 1.80 | 0.14 | 5.59 | 9.21 | 0.55 | 6.62 | 0.57 | 3.29 |
| 10. Petroleum refining | 3.39 | 4.26 | 1.69 | 0.12 | 2.87 | 0.26 | 1.23 | -2.35 | -0.22 | 5.38 |
| 11. Rubber & plastics | 2.24 | -0.23 | 2.47 | 0.16 | 4.03 | 7.83 | 0.03 | 3.70 | -0.43 | -0.30 |
| 12. Leather | 0.57 | -1.15 | -0.88 | -0.07 | 1.27 | 3.24 | 0.16 | -1.86 | -1.57 | -3.09 |
| 13. Stone, clay & glass | 3.18 | 0.09 | -0.28 | 0.08 | 2.27 | 5.62 | 0.77 | 1.97 | -0.30 | 0.08 |
| 14. Primary metals | 2.63 | 0.81 | 0.90 | 0.09 | 0.81 | 5.26 | 0.68 | 2.75 | -0.03 | -1.46 |
| 15. Fabricated metals | 0.78 | -0.32 | 1.13 | 0.00 | 2.73 | 7.27 | 0.33 | 3.19 | -0.04 | -1.29 |
| 16. Industrial machinery | 2.43 | 0.37 | 2.78 | -0.03 | 4.07 | 7.62 | 0.58 | 4.97 | -0.01 | 0.25 |
| 17. Electronic equipment | 0.13 | 0.01 | -1.31 | 0.00 | 0.45 | 7.26 | 0.87 | 2.97 | 0.19 | -1.61 |
| 18. Motor vehicles | 1.16 | -0.31 | 0.17 | 0.16 | 1.89 | 1.37 | 1.24 | 0.11 | 0.23 | 0.99 |
| 19. Other trans. Equip. | 4.23 | -1.23 | 2.53 | 0.04 | 3.35 | 6.58 | 0.48 | 6.59 | 0.29 | 0.36 |
| 20. Misc. manufacturing | 1.18 | -0.67 | 0.59 | 0.02 | 1.33 | 7.66 | 0.12 | 6.56 | 0.16 | 1.40 |
| Total Manufacturing | 2.33 | 0.24 | 0.66 | 0.09 | 2.77 | 3.61 | 0.62 | 0.84 | 0.26 | 0.62 |

## Appendix Table 3. Average Annual Growth Rates of Inputs in Canada and the United States, 1979-1995

| | Canada | | | | | The United States | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | K Input | K Qual. | L Input | L Qual. | U | K Input | K Qual. | L Input | L Qual. | U |
| 1. Food | 1.30 | 0.27 | -0.31 | 0.31 | 1.30 | 1.37 | 0.16 | 0.34 | 0.61 | 1.18 |
| 2. Tobacco | -1.86 | 0.23 | -3.69 | 0.56 | -2.11 | 2.86 | -0.06 | 0.10 | 0.97 | -0.35 |
| 3. Textile | -0.61 | -0.06 | -1.13 | 0.57 | -0.07 | 0.60 | -0.02 | -0.53 | 0.59 | 0.43 |
| 4. Apparel | 1.00 | -0.03 | -2.05 | 0.09 | -0.42 | 2.43 | 0.01 | -0.21 | 0.80 | 1.06 |
| 5. Lumber & wood | -0.14 | 0.32 | -0.27 | 0.16 | 3.36 | 0.38 | 0.06 | 1.03 | 0.80 | 1.89 |
| 6. Furniture | 0.79 | 0.88 | 0.55 | 0.25 | 2.27 | 1.81 | 0.14 | 0.57 | 0.58 | 2.72 |
| 7. Paper | 3.09 | 0.08 | -0.52 | 0.37 | 2.16 | 3.43 | 0.21 | 1.35 | 0.63 | 1.75 |
| 8. Printing | 2.19 | 0.16 | 1.51 | 0.25 | 2.18 | 4.16 | 0.16 | 3.38 | 0.58 | 2.35 |
| 9. Chemicals | 1.29 | 0.23 | 0.29 | 0.36 | 1.52 | 0.30 | 0.08 | -0.20 | 0.72 | 0.38 |
| 10. Petroleum refining | 1.92 | 1.86 | -2.03 | 0.39 | -0.97 | 2.73 | 0.58 | -0.35 | 0.30 | -1.28 |
| 11. Rubber & plastics | 2.64 | 1.26 | 1.99 | 0.28 | 3.32 | 3.01 | 0.17 | 2.56 | 0.52 | 3.48 |
| 12. Leather | -1.12 | -0.29 | -4.73 | 0.28 | -4.48 | -1.46 | 0.08 | -6.27 | 0.81 | -3.30 |
| 13. Stone, clay & glass | -1.13 | 0.44 | -1.25 | 0.24 | -0.43 | 0.05 | 0.10 | -0.37 | 0.47 | -0.24 |
| 14. Primary metals | 1.56 | 0.43 | -1.85 | 0.26 | 1.81 | -0.35 | 0.10 | -2.24 | 0.52 | -1.23 |
| 15. Fabricated metals | -1.66 | 0.13 | -0.50 | 0.33 | -0.20 | -0.29 | 0.11 | -1.23 | 0.58 | 0.95 |
| 16. Industrial machinery | 1.32 | 0.23 | 1.17 | 0.28 | 5.72 | 2.49 | 0.33 | -0.66 | 0.77 | 3.20 |
| 17. Electronic equipment | 3.21 | -0.28 | -0.31 | 0.52 | 4.76 | 2.92 | 0.30 | -0.83 | 0.82 | 4.21 |
| 18. Motor vehicles | 5.83 | 2.71 | 2.06 | 0.15 | 5.08 | 1.94 | -0.01 | 1.18 | 0.57 | 2.59 |
| 19. Other trans. Equip. | 1.91 | 0.28 | -0.14 | 0.23 | 2.88 | 2.36 | 0.31 | -1.60 | 0.47 | 0.51 |
| 20. Misc. manufacturing | 2.14 | 0.56 | 0.85 | 0.32 | 1.21 | 3.02 | 0.40 | 0.87 | 0.78 | 2.16 |
| Total Manufacturing | 1.41 | 0.22 | 0.05 | 0.37 | 2.32 | 1.78 | 0.18 | 0.01 | 0.60 | 1.26 |

**Appendix Table 4. Sources of Output Growth in Canadian Manufacturing Based on Capital Stock Data in Statistics Canada's Klemes Database (average % growth per year)**

| | 1961-1995 | 1961-1973 | 1973-1979 | 1979-1995 |
|---|---|---|---|---|
| Gross Output | 3.48 | 5.98 | 2.52 | 1.97 |
| Contribution of Capital Stock | 0.13 | 0.27 | 0.11 | 0.02 |
| Contribution of Capital Quality | 0.11 | 0.22 | 0.05 | 0.05 |
| Contribution of Hours Worked | 0.19 | 0.58 | 0.13 | -0.08 |
| Contribution of Labor Quality | 0.07 | 0.08 | 0.02 | 0.08 |
| Contribution of Intermediate Inputs | 2.37 | 3.78 | 1.83 | 1.52 |
| TFP Growth | 0.61 | 1.05 | 0.38 | 0.37 |

Figure 1: Total Factor Productivity in Canadian and U.S. Manufacturing, 1961-1995