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Research Paper

The Canadian Productivity Review

User Guide for Statistics Canada's Annual Multifactor Productivity Program

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Abbreviations

CANSIM	Canadian Socio-economic Information Management System
CPA	Canadian Productivity Accounts
GDP	Gross domestic product
IAD	Industry Accounts Division
ICSD	Investment and Capital Stock Division
IEAD	Income and Expenditure Accounts Division
KLEMS	Capital, Labour, Energy, Material and Services Inputs
LFS	Labour Force Survey
MFP	Multifactor Productivity
NAICS	North American Industry Classification System
PID	Public Institutions Division
SCF	Survey of Consumer Finances
SIC	Standard Industrial Classification
SLID	Survey of Labour and Income Dynamics

1. Introduction

The Canadian Productivity Accounts (CPA) of Statistics Canada maintain two multifactor productivity (MFP) programs.

- The **Major Sector Multifactor Productivity Program** develops the indexes of MFP for the total business sector and major industry groups in the business sector.
- The **Industry Multifactor Productivity Program** or the **Industry KLEMS Productivity Program** develops the industry productivity database that includes MFP indexes, output, capital (*K*), labour (*L*), energy (*E*), materials (*M*) and services (*S*) inputs for the individual industries of the business sector at various levels of industry aggregation.

This paper describes the methodologies and data sources that are used to construct the major sector MFP indexes and the industry productivity database (or the KLEMS database). More specifically, this paper is meant to

- provide a background of the major sector MFP program and the industry KLEMS productivity program;
- present the methodology for measuring MFP;
- describe the data sources and data available from the MFP programs;
- present a quality rating of the industry KLEMS productivity data; and
- describe the research agenda related to the MFP program.

In addition to the MFP measures, Statistics Canada’s CPA produces the measure of labour productivity or real gross domestic product (GDP) per hour. A change in labour productivity reflects the change in output that cannot be accounted for by the change in hours worked of all persons. Labour productivity or output per hour differs from MFP in its treatment of capital and labour inputs. Labour productivity—output per hour worked—does not explicitly account for the effects of capital or of changes in labour composition on output growth. As a result, changes in capital intensity (the amount of capital per hour worked) and labour composition (percentage of the growth that comes from higher skilled workers) can influence labour productivity growth.

In contrast, MFP treats capital as an explicit input and, therefore, is net of changes in capital intensity. It measures the extent to which the combined inputs of labour and capital are efficiently used in the production process. Improvements in MFP are associated with technological and organizational changes.

The major-sector MFP program develops the historical series of MFP for the total business sector and major industry groups for the period from 1961 to the most recent year for which annual estimates are possible. The industry KLEMS productivity program develops the historical series of MFP at a more detailed industry level for the period from 1961 to the most recent year of input–output tables (which is published with a three-year lag). The three-year lag in the industry KLEMS productivity program is due to the lag in the publication of the annual input–

output tables that provide the data for constructing gross output and intermediate inputs for the industry KLEMS productivity program.

2. Background

The Canadian Productivity Accounts (CPA) of Statistics Canada are one of the oldest productivity programs in the world. The CPA were initiated in the 1960s and initially focused on labour productivity measures. In the mid-1980s, the CPA were expanded to include measures of multifactor productivity (MFP) (Durand 1996, Baldwin and Harchaoui 2006). In the late 1990s, the CPA made comprehensive revisions to the MFP programs (Baldwin and Harchaoui 2002).

MFP measures reflect output per unit of some combined set of inputs. A change in MFP reflects the change in output that cannot be accounted for by the change in combined inputs. As a result, MFP measures reflect the joint effects of many factors, including new technologies, economies of scale, managerial skills and changes in the organization of production.

Comparisons among MFP measures must be made with an understanding of the underlying definitions used in constructing each measure. Gross output can be combined with capital, labour and intermediate inputs to produce a gross-output-based MFP measure. Alternatively, MFP measures can be based on a value-added measure, in which case value-added is considered as output and capital input and labour inputs are inputs. A sectoral output measure is similar to a gross output measure. The difference is that sectoral output is corrected for deliveries within a sector. At the aggregate level of the economy, sectoral output and value-added-based measures converge.

For the major industry sector MFP program, MFP indexes are based on the value-added output concept. This MFP measures output per combined unit of labour and capital input in the business sector and its major sectors.

For the industry KLEMS productivity program, MFP indexes are based on three alternative output concepts: value-added, gross output and sectoral output. The value-added-based MFP indexes measure output per combined unit of capital and labour inputs. The gross-output-based MFP indexes measure output per combined unit of capital (K), labour (L), energy (E), materials (M) and services (S) inputs. The MFP indexes based on sectoral output are measured by the ratio of sectoral output to the combined units of capital, labour, and sectoral energy, material and services inputs. Inputs in the MFP measures are weighted together using cost weights representing each input's share of total output to develop the combined inputs index.

The three measures of MFP of individual industries serve various purposes. For example, to compare MFP growth at the industry level between Canada and the United States, the MFP measures based on sectoral output must be used as MFP estimates in the United States from the Bureau of Labor Statistics are based on sectoral output.

2.1 Coverage

MFP indexes and related measures in the major sector MFP program are available for

- total business sector, annual data; and
- major sectors of the business sector based on North American Industry Classification System (NAICS) at the S-level of industry aggregation, annual data.

MFP indexes for the total business sector and major sectors cover the period from 1961 to the most recent year for which annual estimates are possible.

MFP indexes and related measures in the industry KLEMS productivity program are available for the individual industries of the business sector at various levels of aggregation:

- industries based on NAICS at the L-level of industry aggregation, annual data;
- industries based on NAICS at the M-level of industry aggregation, annual data; and
- industries based on NAICS at the S-level of industry aggregation, annual data.

The industry KLEMS productivity database covers the period from 1961 to the most recent year of input–output tables.

The historical series of MFP indexes are also available for 122 industries of the business sector based on the Standard Industrial Classification (SIC) for the period from 1961 to 1997.

2.2 Uses

The growth accounting system provides the framework for measurement of MFP. This analysis, based on a production framework, decomposes output growth into the portion that comes from increases in labour and capital and a residual (entitled MFP) that captures the component that is not directly related to the increasing use of inputs.

The MFP programs serve three main purposes (Baldwin and Gu 2007b).

- The MFP measure provides an economic indicator of technical progress and unit factor costs.

The growth accounting framework is used to ask how much growth comes from applying more inputs—and what sort of inputs are more important—as opposed to the residual MFP term. This is important for those who believe the residual term captures externalities that are unrelated to labour or capital accumulations or the manner in which capital is combined with labour, because the residual, by the nature of the production process that is assumed, is essentially disembodied—what economists refer to as neutral technological progress. That is, the shift in the production function does not depend on the particular expansion path followed with regards to capital and labour.

Summary statistics, such as MFP, are more suitable for some purposes than they are for others. They always need to be interpreted in the context of the uses to which they are to be put. A summary statistic that is meant to capture long-term trends, but that is volatile in the short run, should be used to summarize long-run history, not short-run experience. Also, most summary statistics stem from an analytical or theoretical framework that abstracts from some aspects of reality, simplifying reality so that it can be summarized in equation form. For some applications, these simplifications may not be appropriate.

MFP measures are not different in this regard from other summary statistics. Annual productivity growth rates are volatile, but long-run moving averages do show distinct trends and therefore provide useful information in this area. Most statistical agencies calculate them using non-parametric techniques that make very specific simplifying assumptions. For some purposes, these assumptions may be adequate; for others, they are not. For example, the Canadian estimate assumes constant returns to scale. It can be shown, therefore, that the MFP measure estimated without allowance for economies of scale subsumes any effects of scale economies in the estimates of changes in productivity over time. This is a problem for those who want to separate scale effects. It is not for those who believe they should be included in the host of causes behind changes in efficiency. And even if we wanted to separate out these effects, we would have to trade off our ability to produce a statistic that is more suitable for this purpose against the likelihood that an alternate measure would be less accurate because the size of scale economies is notoriously difficult to estimate.

A second example of a simplification that is not unimportant is the nature of technological progress that is assumed in the standard formulation. Technological progress is regarded as a shift in the production function that is not related to the way in which labour and capital are being combined—that the proportionate rate of increase in the amount of output obtained by using a given amount of labour and capital is independent of the amount of labour and capital. This may not be the case. Those who estimate MFP and then regress it on differences in factors used are essentially testing whether this assumption is correct.

- The MFP program allows for the identification of the industrial as well as the input sources of the aggregate labour productivity growth and output growth.

The growth accounting framework also allows us to investigate the extent to which labour productivity is higher than, or the same as, MFP and how much of the difference can be attributed to the fact that the economy is capital intensive—has a large share of output accounted for by the services yielded by capital—or has an increasing capital–labour ratio. Labour productivity is often associated with real wage gains in the long run. Thus, an understanding of whether increases in labour productivity come from MFP—possibly the technological component—or from increasing capital investments per unit of labour input will help the analyst to understand and to quantify the various forces behind economic growth.

Aggregate labour and MFP growth in the business sector in the CPA can be traced to its origins at the industry level. The methodology for the decomposition of aggregate MFP growth is Domar aggregation. When MFP is measured on the basis of value-added for the aggregate business sector and measured on the basis of gross output for individual industries, Domar shows that aggregate MFP growth can be expressed as a weighted average of industry MFP growth using the ratio of nominal industry gross output to nominal aggregate value-added as weights.

A methodology for decomposing aggregate labour productivity growth has been developed by Stiroh (2002). He shows that aggregate labour productivity growth can be expressed as a weighted sum of industry labour productivity growth plus a term that reflects the effect of reallocation of hours on aggregate labour productivity growth:

- The MFP programs provide a characterization of the evolution of partial productivity measures.

The growth accounting framework also allows us to characterize how partial productivity measures—labour productivity and capital productivity—change over time, and what is apparently behind the changes in MFP. It allows us to know whether most of the partial productivity growth is coming from the labour or the capital side.

None of this reveals the key to success—what drives investments, what causes technological advances—but it does allow a country's growth process to be tracked over time and compared with other countries—at least, when the estimates from other countries are similar. Judicious analysis of these trends, combined with outside information on technological advances and innovations, provide an understanding of the reasons for economic success.

3. Methodology

In this section, we present the methodology used for measuring outputs, inputs and multifactor productivity in the multifactor productivity (MFP) programs of Statistics Canada. We follow the growth accounting framework that relates changes in output to changes in factors of production, such as labour, capital, materials and other inputs to the production process. The growth accounting framework was developed by Jorgenson and his associates as outlined in Jorgenson, Gollop and Fraumeni (1987) and more recently in OECD (2001); Jorgenson, Ho and Stiroh (2005); Inklaar, Timmer and van Ark (2006) and Timmer, O'Mahony and van Ark (2007).

3.1 Growth accounting framework

The microeconomic theory of the firm uses a 'production function' to formally describe the relationship between the services of inputs and output.[1] Economists have formalized this using a production function relating output to factors of production (labour and capital).

(1) $Q = F(X_1, X_2, ...X_n, t)$ where X_i represents the *i*'th input and *t* is time.

The components of the growth in output can be investigated using the total differential of (1) with respect to time, that is

(2) $$\frac{dQ}{dt} = \sum \frac{\partial F}{\partial X_i}\frac{dX_i}{dt} + \frac{\partial F}{\partial t}.$$

Equation (2) tells us that output changes can be divided into the underlying components using an accounting identity. The first part is the contribution that increases in labour or capital would be expected to make to output growth. It is just the existing marginal product of labour (capital) multiplied by the change in labour (capital) devoted to production. In addition, output would be expected to increase if the production function shifts outward over time for various reasons, for example, from improvements in technology or other organizational changes that allow the resources that are used in production to produce more than they did previously.

At any point in time, existing techniques allow additional factor inputs (labour, capital) that are applied to the production process to produce additional output. The product of additional factors that are added to the production process times the existing marginal product of those factors provides an estimate of the expected amount of output in a given period. If actual output exceeds this, productivity is said to have increased.

Dividing both sides of (2) by Q gives

(3) $$\frac{dQ}{dt}.\frac{1}{Q} = \frac{1}{Q}.\frac{\partial F}{\partial t} + \sum \frac{\partial F}{\partial X_i}\frac{dX_i}{dt}\frac{1}{Q_i}.$$

Now if we define multifactor productivity growth as

(4) $M\dot{F}P = \frac{1}{Q}.\frac{\partial F}{\partial t}$ and recognizing that $\frac{dX_i}{Qdt} = \frac{X_i}{Q}\dot{X}_i$ (where $\dot{X}_i = d\ln X_i$ is the rate of growth in the *i*'th input) gives

(5) $$\dot{Q} = M\dot{F}P + \sum \frac{\partial F}{\partial X_i}\frac{X_i}{Q}\dot{X}_i.$$

1. Alternatively, theorists sometimes start with a cost function to derive a measure of multifactor productivity.

That is, the rate of output change is equal to the rate of growth in MFP and a component that depends on the rate of growth in factor inputs. The latter term depends also on the marginal product of each factor as well as the term $\frac{X_i}{Q}\ \dot{X}_i$.

This framework can be used to measure $M\dot{F}P$ (the growth in MFP) if measures of the terms $\frac{\partial F}{\partial X_i}\frac{X_i}{Q}$ can be found since output change ($\dot{Q}$) and input change ($\dot{X}_i$) are produced in Canada by the Industry Accounts Division of the System of National Accounts Branch.

In order to find a way to proxy the remaining components, the first order conditions for profit maximization are invoked. In those situations where firms operate by hiring factors so that their marginal cost is just equal to their marginal product,

(6) $$\frac{\partial C}{\partial X_i} = \frac{\partial F}{\partial X_i}P$$ where P is the price of Q and C is total cost ($\equiv \sum P_i X_i$).

Recognizing $P_i = \frac{\partial C}{\partial X_i}$ and substituting into Equation (5) gives

(7) $$\dot{Q} = M\dot{F}P + \sum \frac{P_i X_i}{PQ}\dot{X}_i = M\dot{F}P + \sum s_i \dot{X}_i ,$$

where s_i is factor *i*'s share in output (*PQ*).

If the production function is characterized by constant returns to scale and prices of factors (labour and capital) equal their marginal revenue product, then the share of labour in gross domestic product (GDP) and the share of capital in total product just exhaust total GDP. If not, then the formula has to be modified to

(8) $$\dot{Q} = M\dot{F}P + \sum \varepsilon_{cy}^{-1} \frac{P_i X_i}{C}\dot{X}_i ,$$

where ε_{cy} is the measure of the scale of production (the cost elasticity of output).

This approach allows the statistician to approximate the contribution that each of the factors makes to increases in output in Equation (7) using factor prices and the share of a factor in output.

While this is a simplification of real world processes, its appropriateness depends not on whether it is a simplification, but rather on whether it is adequate for the purposes at hand.[2]

The productivity gains represented by the MFP term occur because producers manage to find more efficient ways of producing goods. These gains originate from many sources: from technological change, organizational change and from exploiting scale economies.

MFP growth measures have been developed as summary statistics to measure the amount of those gains that cannot be attributed to factor inputs. In practice, they are calculated using Equation (7) as the difference between the rate of growth of output and the contribution to this growth of the increase in factor inputs, that is

$$(9) \qquad M\dot{F}P = \dot{Q} - \sum \frac{P_i X_i}{PQ} \dot{X}_i = \dot{Q} - \sum s_i \dot{X}_i \,.$$

While the growth Equation (9) forms the heart of growth accounting, other relationships are sometimes derived from this framework to examine subcomponents.

For example, labour productivity and MFP are directly related. This can be seen using Equation (9) and rewriting with two factors of production—labour (*L*) and capital (*K*).

$$(10) \qquad M\dot{F}P = \dot{Q} - s_l \dot{L} - s_k \dot{K} \,.$$

Then adding and subtracting $\dot{L}$ and rearranging gives

$$(11) \qquad M\dot{F}P = \dot{Q} - \dot{L} + \dot{L} - s_l \dot{L} - s_k \dot{K} = \dot{Q} - \dot{L} + (1 - s_l)\dot{L} - s_k \dot{K} \,.$$

Making use of the identity that $\sum s_i = 1$,

$$(12) \qquad M\dot{F}P = \dot{Q} - \dot{L} + (s_k)\dot{L} - s_k \dot{K} = \dot{Q} - \dot{L} + (s_k)(\dot{K} - \dot{L}) \,.$$

Recognizing that the rate of growth in labour productivity (*LP*) is

$$(13) \qquad \dot{LP} = \frac{dQ/L}{dt} . \frac{1}{Q/L} = \dot{Q} - \dot{L} \,.$$

And the rate of change in the capital–labour ratio is

2. See Baldwin, Gaudreault and Harchaoui (2001) for an illustration of the parametric approach to productivity measurement that removes the effect of scale economies and market imperfections. Once done, the estimate of multifactor productivity so produced varies only slightly from the non-parametric estimate that makes the simplifying assumptions of constant returns to scale.

(14) $$\frac{dK/L}{dt}\cdot\frac{1}{K/L}=\dot{K}-\dot{L}\,.$$

Then Equation (12) tells us that

(15) $$\dot{LP}=\dot{MFP}+s_k\frac{\dot{K}}{L}\,.$$

In other words, the growth in labour productivity is equal to the growth in MFP plus the growth in the capital–labour ratio weighted by the share of capital in gross product. Labour productivity is thus higher when MFP is higher and the amount of capital that workers have to utilize is larger.

Alternately, Equation (10) can be modified by using the identity $\dot{Q}=s_l\dot{Q}+s_k\dot{Q}$. Then rearranging terms gives

(16) $$\dot{MFP}=\dot{Q}-s_l\dot{L}-s_k\dot{K}=s_l\dot{Q}-s_l\dot{L}+s_k\dot{Q}-s_k\dot{K}=s_l(\dot{Q}-\dot{L})+s_k(\dot{Q}-\dot{K})\,.$$

Then, since the rate of growth in capital productivity (KP) is

(17) $$\dot{KP}=\frac{dQ/K}{dt}\cdot\frac{1}{Q/K}=\dot{Q}-\dot{K}.$$

Equation (17) can be written as

(18) $\dot{MFP}=s_l(\dot{LP})+s_k(\dot{KP}),$ where $\dot{KP}$ is the capital productivity growth.

Thus, the growth in MFP is just the weighted average of the growth in labour productivity and the growth in capital productivity.

The Canadian Productivity Accounts (CPA) break down the components of labour and capital inputs into different types. The CPA break labour down into 56 components and capital into 28 asset types, and weight the growth in each type separately (see Gu et al. 2002, Harchaoui and Tarkhani 2002). The rate of growth of each input component is weighted by its share of factor income (wages and capital income, respectively) that is calculated using wage rates of each labour type and unit capital costs for each asset type. This procedure results in a rate of increase in labour and capital input that is substantially higher than the unweighted sum of all labour or all capital and, thus, a lower estimate of MFP.

The equation used to estimate MFP in the CPA takes into account the heterogeneity of both labour and capital and uses the following formula:

(19) $$M\dot{F}P = \dot{Q} - \sum_i s_i \sum_j \left(\frac{w_i^j X_i^j}{\sum w_i^j X_i^j} X_i^j\right),$$

where w_i^j is the cost of factor *I* of type *j* (the wage rate for each type of labour and the user cost of capital for each type of capital) and s_i is the share of each factor (labour and capital) in total GDP. Rewriting gives

(20) $$M\dot{F}P = \dot{Q} - \sum_i s_i \sum_j \left(\frac{w_i^j X_i^j}{\sum w_i^j X_i^j} X_i^j\right) = \dot{Q} - s_l \dot{L} - s_k \dot{K},$$

where $\dot{L}$ and $\dot{K}$ are just the weighted average growth rates of the individual components of *L* and *K* as outlined in Equation (20).

Since labour productivity is usually calculated using the unweighted growth in hours worked ($\dot{H}$), that is,

(21) $$L\dot{P} = \dot{Q} - \dot{H}.$$

Then Equation (15) becomes

(22) $$L\dot{P} = M\dot{F}P + s_k \frac{\dot{K}}{L} + (\dot{L} - \dot{H}) = MFP + s_k \frac{\dot{K}}{H} + s_l \frac{\dot{L}}{H},$$

where *H* is just the rate of change of hours worked summed across all labour categories.

Equation (22) indicates that the growth in labour productivity can be broken into three components: 1) the growth in MFP; 2) a term involving the growth in capital intensity—capital per hour worked; and 3) the labour composition term—the difference between the labour input as calculated here and the simple growth in hours worked that does not consider the difference in 'quality' of workers.

In summary, using the production growth accounting framework allows several relationships to be examined. First, it lets us examine the relative contribution of labour, as opposed to capital, to output growth, as shown in Equation (7). Investments in machinery and equipment, buildings and engineering structures are often perceived to be important and this framework permits a quantification of that importance in a systematic fashion.

Second, this framework permits an estimate of the importance of the residual, which has come to be referred to as MFP. MFP captures the influence of many factors. When the estimate of the effect of increases in labour and capital are derived from assuming that there are constant returns to scale in the production process and that inputs are generally paid their marginal revenue product, the residual captures any economies of scale that are present, along with the effect of technological progress—that is, shifts in the production possibilities curve. When scale effects are relatively small, the estimate of MFP essentially captures technological progress. Technological progress allows an economy to produce more with the same, or less, resource inputs.

While the MFP measure is often used to understand how efficiency is improving in the overall economy, it is not the only productivity measure that is frequently used to assess the amount of productivity gain in the economy. Labour productivity (output per worker or per hour worked) is also often used. The growth accounting framework can be used to understand how the two are related and what is causing divergences between them. As Equation (19) demonstrates, MFP is just a weighted average of the two partial productivity measures—labour and capital productivity. MFP is, therefore, a more comprehensive measure than either labour or capital productivity, in that it takes into account the efficiency with which the economy is transforming both labour and capital into output. Labour productivity is a partial measure since it examines only the efficiency with which the economy transforms one factor—labour.

The accounting framework with the appropriate transformations also yields Equation (15) that expresses labour productivity as a function of MFP and changes in the capital–labour ratio. This equation tells us that labour productivity will generally be greater than MFP—by an amount that depends partially on the rate at which the amount of capital per worker is increasing, and partly on the capital intensity (as measured by capital–labour ratios) of the economy.

Each of Equations (7), (15) and (18) are identities. They are derived from the same framework—though they express the relationships in different ways. The first breaks down the growth in output into two components—the amount that comes from labour and capital and the residual, which is used to represent underlying change in the production process, part of which comes from technological improvements. During this process, the capital–labour ratio often changes (increases) and so too do labour productivity and capital productivity. These variables, taken together, satisfy the relationships expressed in Equations (15) and (18). Labour productivity will be higher when MFP is higher because they both embody technical change. But because of identities, labour productivity is also affected by increases in the capital–labour ratio.

Similarly, the equation for MFP states only that with increases in labour productivity and capital productivity, we should expect to see increases in MFP.

The above growth accounting framework is given in continuous time. Empirical data typically refer to discrete time points, such as individual years in the annual MFP programs of Statistics Canada. For discrete data, the above equations are approximated by a Törnqvist index. The source of output growth—Equation (7)—can be written as

$$\text{(7A)} \qquad \Delta \ln Q_t = \Delta \ln MFP_t + \sum \overline{s}_{it} \Delta \ln X_{it} \,,$$

where $\Delta x_t = x_t - x_{t-1}$ denotes the change between year t-1 and t, $\overline{s}_{it}$ is the two-period average share of input i in the nominal value of output.

The MFP growth Equation (9) can be rewritten as

(9A) $\Delta \ln MFP_t = \Delta \ln Q_t - \sum \overline{s}_{it} \Delta \ln X_{it}$.

The source of labour productivity growth Equation (22) becomes

(22A) $\Delta \ln LP_t = \Delta \ln MFP_t + \overline{s}_{kt} (\Delta \ln K_t - \Delta \ln H_t) + \overline{s}_{lt} (\Delta \ln L_t - \Delta \ln H_t)$.

The above growth accounting framework is appropriate when value-added is used as the output measure. When we use the gross output concept for measuring industry-level MFP growth, we also need to include intermediate inputs in addition to capital and labour in the growth accounting formula (see Jorgenson, Ho and Stiroh 2005).

3.2 Output and intermediate inputs

Statistics Canada's MFP programs provide data on chained-Fisher quantity indices and nominal values of output and intermediate inputs for the individual industries of the business sector. Output is valued at basic prices, while intermediate inputs are valued at purchaser prices. The output of the total business sector is measured as value-added, while the output at the industry level is measured as GDP (or value-added), sectoral output and gross output.[3]

The main source data for estimating output and intermediate inputs for the MFP programs are the annual input–output tables of Statistics Canada. The construction of output and intermediate inputs involves the aggregation of a large number of commodity outputs and intermediate inputs. For all of our aggregations, we use annually chained-Fisher indices.

3. Previously, the measure of MFP for the aggregate business sector was based on real GDP measured at market prices. The real GDP measure at market prices was estimated from the final demand side of the Canadian System of National Accounts.

Notation

We begin by defining the key variables in the annual input–output accounts, and the output and intermediate inputs of the Canadian industries.

c	index for commodity
j	index for industry
T	index for time
PV_{cjt}	make matrix, nominal value of commodity *c* made by industry *j*
V_{cjt}	make matrix, quantity of commodity *c* made by industry *j*
$P_{V,cjt}$	price of commodity *c* made by industry *j*
PU_{cjt}	use matrix, nominal value of commodity input *c* to industry *j*
U_{cjt}	use matrix, quantity of commodity input *c* to industry *j*
$P_{U,cjt}$	price of commodity input *c* to industry *j*
II_{cjt}	intra-industry trade matrix, the quantity of commodity input *c* to industry *j* that is produced by industry *j*
PII_{cjt}	intra-industry trade matrix, nominal value of commodity input *c* to industry *j* that is produced by industry *j*
PM_{ct}	nominal value of imports of commodity *c*
PX_{ct}	nominal value of exports of commodity *c*
PV_{jt}	nominal value of gross output of industry *j*
PA_{jt}	nominal value of value added of industry *j*
PV_{jt}^{GN}	nominal value of sectoral output of industry *j*
$IFQV_{jt}$	Fisher quantity index of gross output of industry *j*
$ILQV_{jt}$	Laspeyres quantity index of gross output of industry *j*
$IPQV_{jt}$	Paasche quantity index of gross output of industry *j*
$IFQA_{jt}$	Fisher quantity index of value added of industry *j*
$ILQA_{jt}$	Laspeyres quantity index of value added of industry *j*
$IPQA_{jt}$	Paasche quantity index of value added of industry *j*
$IFQV_{jt}^{GN}$	Fisher quantity index of sectoral output of industry *j*
$ILQV_{jt}^{GN}$	Laspeyres quantity index of sectoral output of industry *j*
$IPQV_{jt}^{GN}$	Paasche quantity index of sectoral output of industry *j*

The methodology for constructing the Fisher index of output and intermediate inputs presented here uses all three sets of input–output tables: make-and-use tables in current prices; make-and-use tables valued using prices in the previous year (called Lasypeyres prices); and make-and-use tables valued using prices in the subsequent year (called Paasche prices). The chained-Fisher index of output and intermediate inputs in the experimental productivity database is estimated from two sets of make-and-use tables: those valued in current prices and those valued in Laspeyres prices. The modified methodology starts with those two sets of tables, derives implicit price indices for commodity outputs and inputs, and then applies the Fisher aggregation to estimate the chained-Fisher index.

Gross output

The value of gross output for industry *j* is the total value of all of the commodities it makes:

$$PV_{jt} = \sum_{c} PV_{cjt} .$$

The quantity index of gross output for the MFP growth is a chained-Fisher index that is calculated as the geometric mean of the Laspeyres and Paasche indices:

$$\frac{IFQV_{jt}}{IFQV_{jt}} = \left(\frac{ILQV_{jt}}{ILQV_{jt-1}} \frac{IPQV_{jt}}{IPQV_{jt-1}} \right)^{1/2} ,$$

where the Laspeyres quantity index of gross output uses the previous year's prices to aggregate industry products

$$\frac{ILQV_{jt}}{ILQV_{jt-1}} = \frac{\sum_{c} P_{V,cjt-1} V_{cjt}}{\sum_{c} P_{V,cjt-1} V_{cjt-1}} = \frac{\sum_{c} P_{V,cjt-1} V_{cjt}}{\sum_{c} PV_{cjt-1}},$$

and the Paasche quantity index of gross output uses current year prices to aggregate industry products

$$\frac{IPQV_{jt}}{IPQV_{jt-1}} = \frac{\sum_{c} P_{V,cjt} V_{cjt}}{\sum_{c} P_{V,cjt} V_{cjt-1}} = \frac{\sum_{c} PV_{cjt}}{\sum_{c} P_{V,cjt} V_{cjt-1}} .$$

The data for constructing the chained-Fisher index of gross output are obtained from the input–output accounts of Statistics Canada and include:

- make matrix in current prices that provide data on the nominal value of commodity *c* made by industry *j* (PV_{cjt}),

- make matrix in Laspeyres prices that provide data on the value of commodity c made by industry j that are valued in period t-1 ($P_{V,cjt-1}V_{cjt}$), and
- make matrix in Paasche prices that provide data on the value of commodity c made by industry j that are valued in period t+1 ($P_{V,cjt+1}V_{cjt}$).

Intermediate inputs

The value of intermediate inputs for industry j is the total value of the commodities it uses:

$$PU_{jt} = \sum_{c} PU_{cjt} .$$

The quantity index of intermediate inputs can be constructed in a method similar to the one for constructing the quantity index of gross output.

Value-added

The nominal value-added for industry j is the total value of the commodities it makes, minus the total value of the intermediate inputs it uses:

$$PA_{jt} = \sum_{c} PV_{cjt} - \sum_{c} PU_{cjt} .$$

The quantity index of value added is a chained-Fisher index, defined as the geometric mean of the Laspeyres and Paasche indices:

$$\frac{IFQA_{jt}}{IFQA_{jt}} = \left(\frac{ILQA_{jt}}{ILQA_{jt-1}} \frac{IPQA_{jt}}{IPQA_{jt-1}} \right)^{1/2} ,$$

where the Laspeyres quantity index of value added uses the previous year's prices to aggregate industry products and intermediate inputs

$$\frac{ILQA_{jt}}{ILQA_{jt-1}} = \frac{\sum_{c} P_{V,cjt-1}V_{cjt} - \sum_{c} P_{U,cjt-1}U_{cjt}}{\sum_{c} P_{V,cjt-1}V_{cjt-1} - \sum_{c} P_{U,cjt-1}U_{cjt-1}} = \frac{\sum_{c} P_{V,cjt-1}V_{cjt} - \sum_{c} P_{U,cjt-1}U_{cjt}}{\sum_{c} PV_{cjt-1} - \sum_{c} PU_{cjt-1}} ,$$

and the Paasche quantity index of value added uses current year prices to aggregate industry products and intermediate inputs

$$\frac{IPQA_{jt}}{IPQA_{jt-1}} = \frac{\sum_{c} P_{V,cjt}V_{cjt} - \sum_{c} P_{U,cjt}U_{cjt}}{\sum_{c} P_{V,cjt}V_{cjt-1} - \sum_{c} P_{U,cjt}U_{cjt-1}} = \frac{\sum_{c} PV_{cjt} - \sum_{c} PU_{cjt}}{\sum_{c} P_{V,cjt}V_{cjt-1} - \sum_{c} P_{U,cjt}U_{cjt-1}} .$$

The data for constructing the Fisher index of value-added are taken from the input–output accounts of Statistics Canada and include:

- make matrix in current prices that provides data on the value of commodity *c* made by industry *j* (PV_{cjt}),
- make matrix in Laspeyres prices that provides data on the value of commodity *c* made by industry *j* that are valued in period *t*-1 ($P_{V,cjt-1}V_{cjt}$),
- make matrix in Paasche prices that provides data on the value of commodity *c* made by industry *j* that are valued in period *t*+1 ($P_{V,cjt+1}V_{cjt}$),
- use matrix in current prices that provides data on the value of commodity input *c* to industry *j* (PU_{cjt}),
- use matrix in Laspeyres prices that provides data on the value of commodity input *c* to industry *j* that are valued in period *t*-1 ($P_{U,cjt-1}U_{cjt}$), and
- use matrix in Paasche prices that provides data on the value of commodity input *c* to industry *j* that are valued in period *t*+1 ($P_{U,cjt+1}U_{cjt}$).

Sectoral output and sectoral intermediate inputs

The difference between sectoral output and gross output is the treatment of intra-industry trade of intermediate inputs. The amount of intra-industry trade depends on the degree of integration of firms in the industry. Intra-industry trade is small when the industry is highly integrated, and it is large when it is made up of a large number of small firms.

The intra-industry transaction of intermediate inputs is included in the gross output concept while it is netted out in the sectoral output concept. Essentially, the industries for the purpose of calculating sectoral output are considered to be completely integrated and individual firms within industries are combined into a single unit. It has been argued that international comparisons of productivity growth should be based on sectoral output, as it is not sensitive to the difference in the degree of integration between countries (OECD 2001; Inklaar, Timmer and van Ark 2006).

The measures of sectoral output and input can be estimated using the make-and-use tables of the Canadian input–output accounts (see, for example, Inklaar, Timmer and van Ark 2006; Durand 1996; OECD 2001). The nominal value of intra-industry trade of commodity *c* to industry *j* is estimated as

$$PII_{cjt} = \frac{PV_{cjt}}{PV_{ct}} PU_{cjt} \left(1 - \frac{PM_{ct}}{PV_{ct} + PM_{ct} - PX_{ct}}\right).$$

To estimate the intra-industry trade, we have used the fixed product-sales structure assumption where each product has its own sales structure, irrespective of where it is used. $\frac{PV_{cjt}}{PV_{ct}}$ is the share of commodity *c* that is produced by industry *j*. The term in the bracket is the share of total supplies of commodities that are domestically produced. It is equal to 1 minus the share of total supplies of commodities that are imported.

The value of sectoral output of an industry is the total value of the commodities it makes minus the total value of the intermediate inputs that it purchases from firms in the same industry:

$$PV_{jt}^{GN} = \sum_c PV_{cjt} - \sum_c PII_{cjt} .$$

The quantity index of sectoral output for the MFP measures is a Fisher index, defined as the geometric mean of the Laspeyres and Paasche indices:

$$\frac{IFQV_{jt}^{GN}}{IFQV_{jt}^{GN}} = \left(\frac{ILQV_{jt}^{GN}}{ILQV_{jt-1}^{GN}} \frac{IPQV_{jt}^{GN}}{IPQV_{jt-1}^{GN}} \right)^{1/2} ,$$

where the Laspeyres quantity index of value added uses the previous year's prices to aggregate industry products and inputs:

$$\frac{ILQV_{jt}^{GN}}{ILQV_{jt-1}^{GN}} = \frac{\sum_c P_{V,cjt-1} V_{cjt} - \sum_c P_{U,cjt-1} II_{cjt}}{\sum_c P_{V,cjt-1} V_{cjt-1} - \sum_c P_{U,cjt-1} II_{cjt-1}} = \frac{\sum_c P_{V,cjt-1} V_{cjt} - \sum_c P_{U,cjt-1} II_{cjt}}{\sum_c PV_{cjt-1} - \sum_c PII_{cjt-1}},$$

and the Paasche quantity index of sectoral output uses the current year prices to aggregate industry products and inputs:

$$\frac{IPQV_{jt}^{GN}}{IPQV_{jt-1}^{GN}} = \frac{\sum_c P_{V,cjt} V_{cjt} - \sum_c P_{U,cjt} II_{cjt}}{\sum_c P_{V,cjt} V_{cjt-1} - \sum_c P_{U,cjt} II_{cjt-1}} = \frac{\sum_c PV_{cjt} - \sum_c PII_{cjt}}{\sum_c P_{V,cjt} V_{cjt-1} - \sum_c P_{U,cjt} II_{cjt-1}} .$$

The value of sectoral intermediate input is the total value of intermediate inputs minus the total value of intra-industry trade of intermediate inputs:

$$PU_{jt}^{GN} = \sum_c PU_{cjt} - \sum_c PII_{cjt} .$$

The quantity index of sectoral intermediate inputs can be constructed using a method similar to the one used for constructing the quantity index of sectoral output.

The data used for estimating sectoral output include the make-and-use tables in current prices, Lasyepres prices and Paasche prices and the final demand tables in current dollars that provide data on the value of total imports and exports by commodities.

3.3 Capital

Capital input is measured by the services that flow from the stock of capital. This differs from the stock of capital sometimes used in productivity measurement because not all forms of capital provide services at the same rate, just as not all hours worked provide labour services at the same rate. Short-lived assets, such as a car or computer, must provide all of their services in just the few years before they completely depreciate. Office buildings provide their services over decades. So, in a year, a dollar's worth of a car provides relatively more services than a dollar's worth of a building. Because of differences in capital services between assets, capital input can increase not only because investment increases the amount of the capital stocks, but also if investment shifts toward assets—such as equipment—that provide relatively more services per dollar of capital stock.

The asset detail for capital services estimates in the MFP programs consists of 15 types of equipment, and 13 types of structures, and land and inventories for a total of 30 types of assets.

The methodology for estimating capital services is documented in Baldwin and Gu (2007a) and Harchaoui and Tarkhani (2002). Here we mention two main features of capital services measures in Canada.

First, the capital services measure for Statistics Canada's MFP programs is based on the bottom-up approach. This bottom-up approach involves the estimation of capital stock by asset, the aggregation of capital stock of various asset types within each industry to estimate industry capital services, and the aggregation of capital services across industries to derive capital services in the business sector and in the aggregate industry sectors.

Second, investment is benchmarked on the estimates of investment included in the input–output tables in order to ensure consistency between capital input measures and output measures.

Recent studies by Statistics Canada provide new empirical evidence on the depreciation rate for various types of assets (Statistics Canada 2007). As a result, we have incorporated these new estimates of depreciation rates in the capital service estimates.

We have revised the procedure for estimating land stock in the capital services. We have adopted the U.S. Bureau of Labor Statistics methodology for estimating land in Canadian industries. The existing procedure essentially assumes that there is no change in the real value of land in the business sector and it then estimates the real value of land at the industry level based on the industry distribution of property taxes. A brief description of the new procedure is presented here.

The nominal value of land in the agriculture and non-farm business sectors is taken from the balance sheet for the sectors (Statistics Canada CANSIM Tables 002-0020 and 378-0004). The real value of land in those two sectors is set equal to an estimate of total area of the dependable agriculture land for cultivation and total area of urban land.

Data on the value of land at the industry level are scarce. In order to estimate the nominal value of land stock of individual industries, we multiply structure capital stock by land–structure ratios. The land–structure ratios are derived from the corporate balance sheets by sectors, which provided data on book values of land and structures by industry for the period from 1972 to 1987 (CANSIM Table 180-0002).

The real value of land at the industry level is estimated by deflating the nominal value of land using the structure capital's deflators. The final estimates of land stock at the industry level in both current and constant dollars are benchmarked to the aggregate land stock in the total non-farm business sector.

We would also like to mention two empirical issues related to the estimation of capital services.

First, aggregate capital services in the business sector are constructed using the so-called 'bottom-up approach.'[4] Baldwin and Gu (2007a) find that there is a large variation in the endogenous rate of return across industries and the endogenous rate of return is positively correlated with capital stock growth across industries. This suggests that the difference in the rate of return across industries is real, and capital tends to move toward those industries that earn relatively high rates of return. In these cases, it has been argued that we should use the industry-specific return to calculate the user cost of capital and that aggregate capital services should then be calculated by aggregating capital services across industries (Jorgenson, Gollop and Fraumeni 1987). This 'bottom-up' approach for estimating aggregate capital input takes into account the difference in the rate of return across industries and does not require the assumption of perfect mobility of capital inputs across industries.

The second empirical issue involves the way in which we have dealt with negative capital service prices during the estimation procedure. This arises from negative capital income in some periods in a few industries. Capital income is calculated from the input–output system as a residual, and is the difference between nominal value added and labour compensation of paid workers and self-employed workers. Negative capital income and negative capital service prices make aggregation difficult. More importantly, it is not clear that they are in keeping with the spirit of the estimation procedure for capital services. Enterprises are assumed to hire factors to bring the marginal product into equality with these prices. In the case of labour contracts, it is clear what the relevant price is for short-term decisions on hiring. But in the case of capital, the expected long-run capital cost is the relevant concept and short-run fluctuations in return are not likely to heavily influence expectations of long-run rates of returns.

Therefore, to construct aggregate capital service input from asset-level capital stock and service prices, we have made adjustments for those assets whose user costs turn negative in the short run. We have set the user costs of the assets with negative user costs equal to the average user costs of the assets across all industries for those assets that are then adjusted for inter-industry differences in the user cost of capital.

4. The U.S. Bureau of Labor Statistics uses a similar approach to construct aggregate capital services in its business sector multifactor productivity measures.

3.4 Labour

Labour input for MFP measures reflects the compositional shifts of workers by education, experience and class of workers (paid versus self-employed). The growth of labour input (labour services) is an aggregate of the growth of hours worked by different classes of workers, weighted by the hourly wages of each class.

The methodology for estimating labour services is summarized in Gu et al. (2002). Here we mention two main features of labour services estimates for the MFP programs.

First, labour input is a weighted combination of hours worked and takes into account the shifts in composition of hours worked between less- and more-educated workers, between less- and more-experienced workers, and between paid and self-employed workers. But it does not account for changes in the mix of hours worked between industries. The evidence shows that once we take into account the shifts toward more educated and more experienced workers, there is little additional effect on the labour composition index arising from shifts in hours between industries. This differs from the capital input measure. The capital input measure takes into account the shifts in the industry composition of capital input.

Second, the labour composition measure in the MFP programs excludes gender groups in the calculation. Essentially, we assume that the earning differences between male workers and female workers—after controlling for the differences in age, education and two employment categories—is not a result of productivity differences between male and female workers. Rather, it is a result of other factors, such as workplace discrimination.

We have modified the assumptions about the share of labour going to the self-employed workers to reflect changes that occurred during the 1990s. In the past, it had been assumed that the self-employed essentially earned incomes similar to the employed. The Census of Population up to 1990 showed that this was a reasonable assumption; however, during the 1990s, self-employed income fell behind that of production workers. The new measure of self-employed for calculating labour input assumes that the hourly earning of self-employed workers is proportional to that of paid workers with the same level of education and experience. The proportional or scaling factor for each level of education and experience is based on the relative hourly earnings of paid versus self-employed workers derived from the Census of Population.

We have also revised hours worked to reflect new information on jobs and hours per jobs of the business and non-business sectors. Data on labour input for the non-business sector have been revised to make them more compatible with the gross domestic product (GDP) estimates for this sector. Non-business GDP is estimated primarily from the wages and salaries of this sector—along with a small amount of returns to capital that are measured using estimates of depreciation. In this world, labour productivity estimates should be essentially zero. Previous estimates used the Labour Force Survey (LFS) to calculate jobs and hours worked in the non-business sector. However, non-business sector GDP is calculated using the Public Institutions Division’s (PID) estimate of public sector employment. The new estimates of the public sector hours worked make use of the PID estimates along with data from the LFS on hours worked per person in the public sector to estimate hours worked in the non-business sector.

With the development of provincial labour productivity accounts, new benchmarks for the level of labour inputs have been developed that were introduced into the industry productivity database. These benchmarks include changes in the source data—with an increased use of the Survey of Employment, Payrolls and Hours for industry estimates—and changes in the number of holidays built into the hours-worked estimates.

3.5 NAICS backcasting of MFP accounts

Previously, the industry productivity measures were constructed up to 1997 using the Standard Industrial Classification (SIC) system and since then using the North American Industry Classification system (NAICS). For the purposes of time series continuity, new estimates using NAICS have been backcast to 1961. In order to do this, industries that had been originally defined using the old SIC system had to be split into parts to reflect NAICS. This was relatively easy to do in 1997 because most of the source data had been double coded to both classification systems in that year. This allows splitting ratios to be developed for the sources in that year—GDP and its components, labour and investment. These splitting factors could also have been used for previous years. But errors would have been introduced in doing so, unless the components remained relatively similar over time. Unfortunately, the changing importance of industries makes this unlikely. Therefore, the Canadian System of National Accounts decided to use the commodity data that are available in its system of input–output tables to develop splitting ratios for output, intermediate inputs, capital income (or gross operating surplus) and labour income that change over time (Girard and Trau 2004). These were used to develop estimates of GDP, labour and investment that are compatible over time.

The SIC-based investment data for the period from 1961 to 1997 have been converted to the NAICS industries with a detailed SIC to NAICS capital income split in the input–output tables developed for the 1961-to-1997 period. However, the capital income split between NAICS and SIC is too volatile for the following four industries: textile and textile products, wood, publishing, and paper and allied products. As such, we have chosen the GDP split for those four industries when converting investment data from SIC to NAICS.

The above procedure for estimating NAICS-based investment series is also adopted for converting labour estimates from SIC to NAICS. The wage/salaries split between SIC and NAICS in the input–output tables is used to convert hours and jobs estimates of paid workers from SIC to NAICS. The mixed income split between SIC and NAICS is used to convert hours and jobs estimates of self-employed workers from SIC to NAICS.

Other NAICS-based data are available from the LFS on labour and from the Investment and Capital Stock Division on investment that use fixed weights. These data are not compatible with the GDP backcast data.

The NAICS-based data on investment and labour in the MFP program have two main advantages over other industry series based on NAICS.

- First, our procedures for converting industry series from SIC to NAICS are consistent for investment, labour and GDP estimates. The consistency between GDP, capital and labour are essential when we combine industry estimates on GDP, labour and capital to obtain labour, capital and MFP estimates by industry, based on NAICS.

- Second, investment data at the industry level are now benchmarked on the estimates of investment included in the input–output tables of the SNA. This further improves the consistency between the output estimates and the investment and capital services estimates in the NAICS-based productivity measures.

The method for converting the investment estimates from SIC to NAICS involves the following steps.

- First, the data on total investment in current dollars by the 29 industries based on SIC are obtained from the final demand tables from 1961 to 1997. The final demand tables are valued at purchaser prices. These 29 industries are listed in Table 1.
- Second, SIC-based investment estimates were converted to the 29 NAICS industries using a detailed SIC-NAICS capital income concordance developed for the period from 1961 to 1997. The capital income (or gross operating surplus) concordance is prepared by the Input–Output Division as a part of their conversion of the input–output tables from SIC to NAICS. It captures the changes in the share of a SIC's capital income that is allocated to a NAICS industry.
- Third, for four SIC industries—primary textile and textile product; wood; paper and allied products; and printing, publishing and allied industries—we decided to use the SIC-NAICS GDP concordance for the 1961-to-1997 period. The capital income shares of those SIC industries that are allocated to NAICS industries are too volatile. This improvement is a result of consultations with experts in the Input–Output Division that prepared the NAICS-based input–output tables.
- Fourth, the estimated nominal investment for the 29 NAICS industries from the input–output accounts is used as a benchmark for the nominal investment by industry at the L-level of NAICS industry aggregation from the Investment and Capital Stock Division (ICSD).
- Fifth, the benchmarked nominal investment by assets and NAICS industries are deflated to obtain investment in constant dollars using the asset-specific price deflators from the ICSD.

We have compared the estimates of NAICS-based investment that use the changing splitting ratios with those from ICSD. Overall, the difference is small for those NAICS industries that do not involve splitting SIC industries. But the difference is large for those NAICS industries that are obtained by splitting the SIC industries.

Table 1
Industries based on SIC[1] in the final demand tables, 1961 to 1997

	Industries
1	Agriculture and fishing industries
2	Logging and forestry industries
3	Mining, quarrying and oil wells industries
4	Food and beverage industries
5	Tobacco products industries
6	Rubber and plastic products industries
7	Leather and allied products industries
8	Primary textile and textile products
9	Clothing industries
10	Wood industries
11	Furniture and fixture industries
12	Paper and allied products industries
13	Printing, publishing and allied industries
14	Primary metal and fabricated metal products
15	Machinery industries (except electrical machinery)
16	Transportation equipment industries
17	Electrical and electronic products
18	Non-metallic mineral products industries
19	Refined petroleum and coal products
20	Chemical and chemical products
21	Other manufacturing industries
22	Construction industries
23	Other utility industry
24	Transportation industries
25	Communication
26	Wholesale and retail trade industries
27	Finance, insurance and real estate
28	Other services (except government)
29	Government sector

1. Standard Industrial Classification.

4. Data

4.1 Data available from the annual major sector MFP program

The data from the annual major-sector multifactor productivity (MFP) program are available from CANSIM Table 383-0021. Table 2 presents the full list of variables that include:

- Annual indexes of MFP, output per hour worked and output per unit of capital services for the aggregate business sector and the major sectors of the business sector, published in Statistics Canada's *The Daily* release.
- Annual measures of capital services, composition-adjusted labour services, and combined labour and capital inputs for the business sector and the major sectors of the business sector.
- Labour input is divided into three types: workers with primary or secondary education; workers with some or completed post-secondary education; and workers with a university degree or above.
- Capital input is divided into capital services of information and communication technologies and capital services of non-information and communication technologies.

Table 2
The list of variables in the major sector multifactor productivity program

1	Multifactor productivity (hours worked)
2	Labour productivity
3	Capital productivity
4	Real gross domestic product (GDP)
5	Labour input (labour services)
6	Hours worked
7	Labour composition
8	Labour input of workers with primary or secondary education
9	Labour input of workers with some or completed post-secondary certificate or diploma
10	Labour input of workers with university degree or above
11	Capital input
12	Capital stock
13	Capital composition
14	Capital input of information and communications technologies
15	Capital input of non-information and communications technologies
16	Combined labour and capital inputs
17	Gross domestic product (GDP) (dollars)
18	Labour compensation (dollars)
19	Labour compensation of workers with primary or secondary education (dollars)
20	Labour compensation of workers with some or completed post-secondary certificate or diploma (dollars)
21	Labour compensation of workers with university degree or above (dollars)
22	Capital cost (dollars)
23	Capital cost of information and communications technologies (dollars)
24	Capital cost of non-information and communications technologies (dollars)
25	Contribution of capital intensity to labour productivity growth
26	Contribution of labour composition to labour productivity growth

The industries for which data are available from the major-sector MFP program are presented in Table 3.

Table 3
Industries in the major-sector multifactor productivity program

1	Business sector
2	Agriculture, forestry, fishing and hunting [11]
3	Mining and oil and gas extraction [21]
4	Utilities [22]
5	Construction [23]
6	Manufacturing [31-33]
7	Wholesale trade [41]
8	Retail trade [44-45]
9	Transportation and warehousing [48-49]
10	Information and cultural industries [51]
11	Finance, insurance, real estate and renting and leasing
12	Professional, scientific and technical services [54]
13	Other services (except public administration)
14	Business sector, goods, special aggregation
15	Business sector, services, special aggregation
16	Non-durable manufacturing, special aggregation
17	Durable manufacturing, special aggregation

4.2 Data available from the industry KLEMS productivity program

The industry KLEMS productivity program produces annual indexes of industry MFP indexes that include capital (*K*), labour (*L*), energy (*E*), materials (*M*) and services (*S*). The full list of variables in the industry KLEMS database is presented in Table 4.

While the industry KLEMS productivity program develops three measures of MFP based on gross output, sectoral output and value-added as shown in Table 4, only MFP measures based on gross output and value-added are available from CANSIM. The MFP measure based on sectoral output and associated sectoral output and sectoral intermediate input measures are available for research purposes.

Table 4
The list of variables in the industry KLEMS database

Productivity measures
LPA = Real gross domestic product per hour worked (Index, 2002=100)
LPV = Real gross output per hour worked (Index, 2002=100)
MFPA = Multifactor productivity based on gross domestic product (Index, 2002=100)
MFPV = Multifactor productivity based on gross output (Index, 2002=100)
MFPV_GN = Multifactor productivity based on sectoral output (Index, 2002=100)

Volume indices
IFQA = Quantity index of gross domestic product (Index, 2002=100)
IFQL = Quantity index of labour input (labour services) (Index, 2002=100)
IFQH = Hours worked of all persons (millions)
IFQLQ = Quantity index of labour quality (Index, 2002=100)
IFQK = Quantity index of capital services (Index, 2002=100)
IFQZ = Quantity index of net capital stock (Index, 2002=100)
IFQKL = Quantity index of labour and capital inputs (Index, 2002=100)
IFQKLU = Quantity index of all inputs: capital, labour and intermediate inputs (Index, 2002=100)

IFQV = Quantity index of gross output (Index, 2002=100)
IFQU = Quantity index of intermediate inputs(Index, 2002=100)
IFQE = Quantity index of energy input (Index, 2002=100)
IFQM = Quantity index of material input (Index, 2002=100)
IFQS = Quantity index of services input (Index, 2002=100)

IFQV_GN = Quantity index of sectoral output (Index, 2002=100)
IFQU_GN = Quantity index of sectoral intermediate inputs(Index, 2002=100)
IFQE_GN = Quantity index of sectoral energy input (Index, 2002=100)
IFQM_GN = Quantity index of sectoral material input (Index, 2002=100)
IFQS_GN = Quantity index of sectoral services input (Index, 2002=100)

Price indices
IFPA = Price index of gross domestic product (Index, 2002=100)
IFPK = Price index of capital services (Index, 2002=100)
IFPL = Price index of labour input (Index, 2002=100)

IFPV = Price index of gross output (Index, 2002=100)
IFPU = Price index of intermediate inputs(Index, 2002=100)
IFPE = Price index of energy input (Index, 2002=100)
IFPM = Price index of material input (Index, 2002=100)
IFPS = Price index of services input (Index, 2002=100)
IFPV_GN = Price index of sectoral output (Index, 2002=100)
IFPU_GN = Price index of sectoral intermediate inputs(Index, 2002=100)
IFPE_GN = Price index of sectoral energy input (Index, 2002=100)
IFPM_GN = Price index of sectoral material input (Index, 2002=100)
IFPS_GN = Price index of sectoral services input (Index, 2002=100)

Nominal values
PAA = Gross domestic product in current prices (million dollars)
PKK = Cost of capital services (million dollars)
PLL = Cost of labour input (million dollars)

PVV = Gross output in current prices (million dollars)
PUU = Cost of intermediate inputs (million dollars)
PEE = Cost of energy input (million dollars)

Table 4
The list of variables in the industry KLEMS database (concluded)

PMM = Cost of material input (million dollars)
PSS = Cost of services input (million dollars)

PVV_GN = Sectoral output in current prices (million dollars)
PUU_GN = Cost of sectoral intermediate inputs (million dollars)
PEE_GN = Cost of sectoral energy input (million dollars)
PMM_GN = Cost of sectoral material input (million dollars)
PSS_GN = Cost of sectoral services input (million dollars)

Contribution to labour productivity based on gross output
ContrK_LPV = Contribution of capital intensity
ContrL_LPV = Contribution of changes in labour composition
ContrU_LPV = Contribution of intermediate-input intensity

The industry KLEMS productivity database is produced at the S, M and L levels of industry aggregation used in the Input/Output tables. The KLEMS database at the more aggregated S and M levels of industries is available from CANSIM Table 383-0022. The data at the more detailed L level of industry aggregation are made available for research purposes.

Table 5 presents the list of variables available in CANSIM Table 383-0022. The list of industries in CANSIM Table 383-0022 is presented in Table 6.

Table 5
List of variables in the KLEMS database available from CANSIM Table 383-0022

1	Multifactor productivity based on gross output
2	Multifactor productivity based on value-added
3	Labour productivity based on gross output and hours worked
4	Labour productivity based on value-added and hours worked
5	Real gross output
6	Real gross domestic product (GDP)
7	Labour input (labour services)
8	Hours worked
9	Labour composition
10	Capital input
11	Combined labour and capital inputs
12	Intermediate inputs
13	Energy input
14	Material input
15	Services input
16	Combined units of all inputs
17	Gross output (dollars)
18	Gross domestic product (GDP) (dollars)
19	Labour compensation (dollars)
20	Capital cost (dollars)
21	Cost of intermediate inputs (dollars)
22	Cost of energy input (dollars)
23	Cost of material input (dollars)
24	Cost of services input (dollars)
25	Contribution of capital intensity to growth in labour productivity based on gross output
26	Contribution of intermediate input intensity to growth in labour productivity based on gross output
27	Contribution of labour composition to growth in labour productivity based on gross output

Table 6
Industries at the S- and M-level of industry aggregation in CANSIM Table 383-0022

1	Agriculture, forestry, fishing and hunting [11]
2	Crop and animal production
3	Forestry and logging [113]
4	Fishing, hunting and trapping [114]
5	Support activities for agriculture and forestry [115]
6	Mining and oil and gas extraction [21]
7	Oil and gas extraction [211]
8	Mining (except oil and gas) [212]
9	Support activities for mining and oil and gas extraction [213]
10	Utilities [221]
11	Electric power generation, transmission and distribution [2211]
12	Natural gas distribution, water and other systems
13	Construction [23]
14	Manufacturing [31-33]
15	Food manufacturing [311]
16	Beverage and tobacco product manufacturing [312]
17	Textile and textile product mills
18	Clothing manufacturing [315]
19	Leather and allied product manufacturing [316]
20	Wood product manufacturing [321]
21	Paper manufacturing [322]
22	Printing and related support activities [323]
23	Petroleum and coal products manufacturing [324]
24	Chemical manufacturing [325]
25	Plastics and rubber products manufacturing [326]
26	Non-metallic mineral product manufacturing [327]
27	Primary metal manufacturing [331]
28	Fabricated metal product manufacturing [332]
29	Machinery manufacturing [333]
30	Computer and electronic product manufacturing [334]
31	Electrical equipment, appliance and component manufacturing [335]
32	Transportation equipment manufacturing [336]
33	Furniture and related product manufacturing [337]
34	Miscellaneous manufacturing [339]
35	Wholesale trade [41]
36	Retail trade [44-45]
37	Transportation and warehousing [48-49]
38	Air, rail, water and scenic and sightseeing transportation and support activities for transportation
39	Truck transportation [484]
40	Transit and ground passenger transportation [485]
41	Pipeline transportation [486]
42	Postal service and couriers and messengers
43	Warehousing and storage [493]
44	Information and cultural industries [51]
45	Motion picture and sound recording industries [512]
46	Broadcasting and telecommunications [513]
47	Publishing industries, information services and data processing services
48	Finance, insurance, real estate and renting and leasing
49	Professional, scientific and technical services [54]
50	Administrative and support, waste management and remediation services [56]
51	Administrative and support services [561]
52	Waste management and remediation services [562]
53	Educational services (except universities)

Table 6
Industries at the S- and M-level of industry aggregation in CANSIM Table 383-0022
(concluded)

54	Health care and social assistance (except hospitals)
55	Arts, entertainment and recreation [71]
56	Accommodation and food services [72]
57	Other services (except public administration) [81]
58	Repair and maintenance [811]
59	Religious, grant-making, civic, and professional and similar organizations [813]
60	Personal and laundry services and private households

To develop the capital services measures for the MFP indexes, we have developed a capital and investment database by assets. The asset detail consists of 15 types of equipment, and 13 types of structures, and land and inventories for a total of 30 types of assets.

We have also developed a labour input database on hours and compensation of workers that are cross-classified by education, age, class of workers, gender and industries. The data on capital by assets and on labour by types of workers are used to develop capital services and labour services estimates.

4.3 Data sources

For the period up to the most recent year for which the input–output table is available, the major sector MFP program and the industry KLEMS productivity program use similar data. For the three years following the most recent input–output tables, the major sector MFP program obtains additional data on output, capital and labour from various data sources. These data are projections and subject to annual revisions for the first three years after they are issued.

4.3.1 Output

MFP indexes can be calculated using three distinct measures of real output: GDP at basic prices, gross output at basic prices and sectoral output at basic prices.

For the major sector MFP program, output is defined as real GDP. For all but the most recent three years, the annual estimates of real GDP are derived from annual input–output tables. For the three years following the most recent input–output tables, the estimates of real GDP are projections obtained from the Industry Accounts Division.

For the industry KLEMS productivity program, output is defined as either real GDP or gross output or sectoral output. All three measures of output are derived from the annual input–output tables.

The output of the total business sector in the annual MFP program of the Canadian Productivity Accounts (CPA) is measured as value-added at basic prices. The estimate of value-added at basic prices has been calculated using the ‘bottom-up’ approach, by aggregating all industries in the business sector. This differs from the output measure of the total business sector in the quarterly program of the CPA. The output of the total business sector in the quarterly program is based on

GDP at market prices. The estimate of GDP at market prices has been calculated using the ‘top-down’ approach—by subtracting several non-business sector components from final demand. These two approaches give slightly different growth rates in the short run but are the same over longer periods of time.

The difference in the output of the total business sector in the annual program and quarterly program of the CPA can be attributed to a number of factors. First, the value-added output of the total business sector in the annual program is valued at basic prices, while the value-added output in the quarterly program is valued at market prices. The difference between value-added estimated at market prices and value-added at basic prices is taxes on products less subsidies on products.

Second, the estimate of real value-added calculated using the bottom-up and top-down approach involves the chained-Fisher aggregation of different components. Real value-added based on the bottom-up approach is calculated from the aggregation of industry value-added estimates, while real value-added based on the top-down approach involves the aggregation of individual components of the final demand. As a result, the two estimates are not identical.

Third, the revision cycle differs for the two estimates of output of the total business sector. The output estimates of the total business sector are preliminary and subject to revision for the period from the most recent year of input–output tables to the reference year for which annual estimates are possible. The output and productivity estimates based on the top-down approach are revised in May of each year, whereas the output and productivity estimates based on the bottom-up approach are revised in November of each year.

Fourth, the imputed rent of owner-occupied dwellings is treated differently in the two estimates of output of the business sector. The imputed rent in the top-down approach does not exclude all of the intermediate inputs, whereas it does in the bottom-up approach.

Table 7 presents the list of source data for estimating output for the major sector MFP program and industry KLEMS productivity program.

Table 7
The list of source data for the annual multifactor productivity (MFP) programs

Data from annual input–output accounts

Make tables at basic prices
- Current dollars
- Laspeyres dollars
- Paasche dollars

Use tables at purchaser prices
- Current dollars
- Laspeyres dollars
- Paasche dollars

Final demand tables in current dollars, purchaser prices

Additional data for the major sector MFP programs for the three years following the most recent input-output tables

Table 379-0017 – Gross domestic product (GDP) at basic prices, by NAICS, annual (dollars x 1,000,000)

Table 379-0020 – Gross domestic product (GDP) at basic prices, special industry aggregations based on NAICS, annual (dollars x 1,000,000)

4.3.2 Labour

Hours and employment data are primarily drawn from the Statistics Canada Labour Productivity Program, which provides data on total employment and hours worked of paid workers and self-employed workers by industry.

Labour composition data are based on household surveys and the censuses of population:

- Survey of Consumer Finance (SCF)
- Labour Force Survey (LFS)
- Survey of Labour and Income Dynamics (SLID)
- Census of Population.

The labour input is an aggregate of the hours worked of all persons classified by their education, work experience and class of employment (paid versus self-employed workers). This aggregate labour input measure is constructed by aggregating hours at work data for each of 56 types of workers classified by their educational attainment (4), work experience (7) and class of workers (2) using an annual chained-Fisher index. The effect of Fisher aggregation is to produce a measure of labour input that reflects both changes in total hours of work and changes in the composition of workers. A shift in the work force toward more educated and experienced workers generally results in faster labour input growth based on this measure. The difference between the growth rate of labour input and total hours at work is defined to be the growth rate of labour composition and is, loosely, a measure of the change in the skill level of the work force.

Table 8
Classification of workers for calculating labour composition

Labour characteristics	Number of categories	Description
Age group	7	15 to 17, 18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65+
Education	4	Primary, secondary, post-secondary, university
Class of workers	2	Paid workers, self-employed workers

The data components for the construction of labour composition are annual estimates of hours worked and labour compensation for the cross-tabulation between 112 types of workers and individual industries. The workers in the annual estimates of hours worked and labour compensation are disaggregated by seven age groups, four education levels and two employment categories as listed in Table 8, plus two gender groups for a total of 112 types of worker.

While the annual estimates of hours and labour compensation provide data on two gender groups, the labour composition measure in the MFP programs excludes gender groups in the calculation. Essentially, we assume that the earning differences between male workers and female workers—after controlling for differences in age, education and two employment categories—is not a result of productivity differences between male and female workers. Rather, it is a result of other factors, such as workplace discrimination. Excluding the gender effect on the labour composition measure has a minimal impact on our estimate of the growth in labour services (see Gu et al. 2002).

Two sets of data are used to construct consistent estimates of hours worked and labour compensation for the cross-tabulation between 112 types of workers and individual industries:

- data from Statistics Canada's labour productivity program by industry and employment category (paid workers, and self-employed workers and unpaid family workers) for every year since 1961; and
- data by industry, class of worker, age, gender and level of schooling that were constructed from the Census of Population and various household surveys (LFS, SCF and SLID).

Data on hours worked and earnings by industry and employment categories from Statistics Canada's labour productivity account. The concept of hours worked for the Statistics Canada's productivity program is essentially the one recommended in the 1993 System of National Accounts (SNA) manual. Hours worked are derived from the total number of hours that a person spends at work, whether they are paid hours or not. In general, it encompasses both regular hours and overtime, including breaks, travel time, on-the-job training time and time lost because of temporary stoppages during which employees remain at their posts. Hours worked do not include time lost due to strikes or lockouts, annual vacations, statutory holidays, sick leave, maternity leave or leave for personal responsibilities.

Estimates of hours worked are broken down into two main employment categories: paid employment, and self-employment and unpaid family employment. The unpaid employment occurs mostly in industries with significant numbers of family businesses (primarily agriculture and retail trade).

For productivity calculations at Statistics Canada, the number of hours worked is obtained by multiplying the number of jobs by the average annual hours worked. In general, estimates of the number of paid jobs are based on combined employment data from household surveys (LFS, SLID and censuses) and business surveys (Survey of Employment, Payrolls and Hours, Annual Survey of Manufactures, Census of Mines, etc.). Data for other employment categories are taken directly from the LFS. Except for some mining and manufacturing industries, all data on average hours worked also come from the LFS. Data on hours worked by sector and by industry are consistent with the SNA and are adjusted for known statistical discontinuities.

Labour compensation as defined for the productivity program includes all payments in cash or in kind that Canadian producers make to workers in return for their services. It includes labour income such as wages and salaries (including bonuses, tips, taxable allowances and back pay), supplementary income of paid workers (various employer contributions) and the implicit labour income of self-employed workers.

The hourly earnings of workers are given by the quotient of total compensation paid for all jobs divided by total hours worked.

Income data for all paid employment originate directly from the estimates of employment income produced by the Income and Expenditure Accounts. In the case of self-employed workers, the combined labour income was obtained by imputation in the past, using the assumption that the value of an hour worked by a self-employed worker was equal to the value of an hour worked by a paid worker (at the average rate) in the same industry. The same imputation approach is used to produce data for unpaid family workers. In addition, employment income for certain professionals (physicians, lawyers, dentists, accountants and engineers) is derived from income tax statistics.

The assumptions about the share of labour going to the self-employed have been modified to reflect changes that occurred during the 1990s. While the Census of Population up to 1990 showed this was a reasonable assumption, during the 1990s self-employed income fell behind that of production workers (see Baldwin and Chowhan 2003). In the new productivity accounts, the wage or income going to the self-employed comes directly from the census and the LFS. It is assumed that the hourly earnings of self-employed workers is proportional to that of paid workers with the same level of education and experience. The proportional or scaling factor is based on the relative hourly earnings of paid and self-employed workers from the Census of Population.

Data on hours worked and earnings by industry, gender, age group, education and employment categories from household surveys and the population census. Data from the Census of Population for 1961, 1971, 1981, 1986, 1991, 1996 and 2001 were used to construct hours worked and labour compensation for the census reference years (1960, 1970, 1980, 1985, 1990, 1995 and 2000). For the non-censual years prior to 1976, data on hours worked and earnings are estimated from a linear interpolation of the data from two adjacent censuses. After 1976, the hours data derived from a linear interpolation of the two adjacent censuses are reconciled with the data on hours worked by worker characteristics in the aggregate business sector from LFS. The hourly earnings data derived from a linear interpolation of the two adjacent censuses are adjusted to the hourly earning estimates from the three household surveys: the SCF over the 1976 to 1993 period, the SLID for 1993 to 1997, and the LFS after 1997. Starting in 1997, the LFS collected data that can be used for estimating hourly earnings. As such, we have used the LFS to estimate hourly earnings after 1997.

In January 1990, LFS revised the questions related to educational attainment of the respondents. From 1976 to 1989, post-secondary education was limited to education that normally requires high-school graduation. After 1990, post-secondary education included any education that could be counted toward a degree, certificate or diploma from educational institutions. The change caused a reallocation of respondents from secondary to post-secondary education. To ensure the data are consistent over time, we chose not to use the pre-1990 data on hours worked by education from LFS. The data on hours worked by education prior to 1990 were calculated instead as a linear interpolation of the two adjacent censuses.

Since the 1961 Census data are not available in electronic form, the iterative fitting method (see Jorgenson, Gollop and Fraumeni 1987) was used to estimate data on hours worked and hourly earnings by industry, gender, age group, education and employment classes (see Gu et al. 2002 for details).

Combining the data from household surveys and the Census of Population with the estimates of the productivity program. The data on hours worked and earnings that are constructed from household surveys and the Census of Population are reconciled with the annual benchmark data used in Statistics Canada's labour productivity program. The two sets of data were reconciled using their common variables (industry and class of worker category). Constructing the hours-worked data required reconciliation, since number of hours worked derived from the census refers to the census week while earnings and number of weeks worked refer to the previous year. Hours worked are computed by multiplying the average hours worked during the census reference week by the number of weeks worked in the previous year.

Once the data on annual hours worked and hourly earnings by industry, age group, gender, level of education and employment category were collected, the indices of labour composition were constructed for the business sector.

4.3.3 Capital

The capital services measure for the MFP programs of Statistics Canada is similar to the measure that is adopted in the MFP programs of the U.S. Bureau of Labor Statistics. It is based on the bottom-up approach. This bottom-up approach involves the estimation of capital stock, the aggregation of capital stock of various asset types within each industry to estimate industry capital services, and the aggregation of capital services across industries to derive capital services in the business sector and in the aggregate industry sectors.

The asset detail for capital services estimates in the MFP programs consists of 15 types of equipment, and 13 types of structures, and land and inventories for a total of 30 types of assets. The list of assets is presented in Table 8.

The major sector MFP program develops the indexes of capital services and MFP for a period up to the most recent year, while the industry KLEMS productivity program covers the period up to most recent year of the input–output tables. For the overlapping years between the two MFP programs (the period up to the most recent input–output tables), source data and capital services estimates are identical in the two MFP programs. For the three years following the most recent input–output tables, the major sector MFP program develops productivity measures that are based on a preliminary estimate of capital services.

Below we discuss the source data for constructing capital services input in the MFP programs.

Fixed reproducible assets (equipment and structures). The capital input includes 28 fixed reproducible assets (15 types of equipment and 13 types of structure). To estimate capital services, we start with the construction of investment in equipment and structures. The investments in each of 28 types of assets are then deflated, weighted and added together, resulting in net capital stock. To implement this perpetual inventory method, we assume that investment follows the geometric depreciation pattern. The depreciation rates for each of the 28 types of equipment and structures are listed in Table 9.

The construction of investment in equipment and structures begins with source data on investment by assets from the Investment and Capital Stock Division (ICSD) of Statistics Canada. To ensure the consistency between capital input and output, we have benchmarked the investment data from the ICSD to the total value of investment at the industry level in the annual output accounts.

The above source data produce investment in 28 types of equipment and structures for the period up to the most recent year of input–output tables for the two MFP programs. As the major sector MFP programs also develop capital services for the years following the most recent input–output tables, additional data are required to estimate capital services for those post input–output years. The additional data have much less asset detail and are obtained from two main sources: investment in three main asset categories (M&E, building structures and engineering structures) at the industry level from the ICSD; and investment in 12 types of equipment and structures in the total business sector from the expenditure side of the income and expenditure accounts (Table 380-0026).

Table 9
List of assets and their depreciation rates in the multifactor productivity programs

Asset type	Geometric depreciation rate
1. Office furniture, furnishing	0.24
2. Non-office furniture, furnishings and fixtures	0.21
3. Motors, generators, and transformers	0.13
4. Computer-assisted process	0.17
5. Non-computer-assisted process	0.16
6. Communication equipment	0.22
7. Tractors and heavy construction equipment	0.17
8. Computers, associated hardware and word processors	0.47
9. Trucks, vans, truck tractors, truck trailers and major replacement parts	0.23
10. Automobiles and major replacement parts	0.28
11. Other machinery and equipment	0.20
12. Electrical equipment and scientific devices	0.22
13. Other transportation equipment	0.10
14. Pollution abatement and control equipment	0.15
15. Software	0.55
16. Plants for manufacturing	0.09
17. Farm buildings, maintenance garages, and warehouses	0.08
18. Office buildings	0.06
19. Shopping centers and accommodations	0.07
20. Passenger terminals, warehouses	0.07
21. Other buildings	0.06
22. Institutional building construction	0.06
23. Transportation engineering construction	0.07
24. Electric power engineering construction	0.06
25. Communication engineering construction	0.12
26. Downstream oil and gas engineering facilities	0.07
27. Upstream oil and gas engineering facilities	0.13
28. Other engineering construction	0.08
29. Land	0.00
30. Inventories	0.00

Source: Statistics Canada, Depreciation Rates for the Productivity Accounts, 2006.

To develop the capital services measures for the period following the most recent year of input–output tables, we need to generate investment in current and constant dollars in the 28 types of fixed reproducible assets at the industry level for the period. To generate investment in current dollars, we first apply the average composition of the 28 asset categories in three years prior to the most recent input–output tables to nominal investment data after the most recent input–output tables. This provides initial estimates of nominal investment in the 28 types of assets for the period following the recent input–output tables. Those initial estimates are then adjusted to the nominal investment in 12 assets for the business and non-business sectors, and the nominal investment in three main assets at the NAICS L-level of industry aggregation, using the method of iterative proportional fitting.

The projected nominal investments in 28 asset types are deflated to provide estimates of investment in constant dollars. The investment price deflators for the 28 assets are proxied by the investment price deflators for the 12 assets that are available from the expenditure side of the Income and Expenditure Accounts (Table 380-0026).

As the output of the lessors of real estate includes the paid rents of rental residential buildings, capital input to the lessors of real estate industry needs to be adjusted to include investment in rental buildings. Data on investment in rental residential buildings are not available. For the annual MFP programs, we divide the total investment in residential building into rental building and owner-occupied dwelling using paid rents for rental buildings and imputed rents for owner-occupied dwelling as the split ratios. The investment in residential buildings and paid and imputed rents are available from the Income and Expenditure Accounts. On average, we find that about 30% of total rents are paid rents and the remaining 70% are imputed rents.

Table 10 presents the source data for investment in 28 types of fixed reproducible assets in the MFP programs.

Table 10
Source data for investment in fixed reproducible assets

Data	Reference period	Source division
Investment in current dollars in 175 asset types, by industries	1961 to most recent input–output tables	ICSD[1]
Price deflators for investment in 175 asset types	1961 to most recent input–output tables	ICSD[1]
Investment in current and constant dollars in three assets (M&E, building and engineering), by industries	1926 to most recent year	ICSD[1]
Total investment in equipment and structures in current dollars at the industry level	1961 to most recent input–output tables	IAD[2]
Total investment in 12 types of equipment and structures in the total business sector	1981 to most recent year	IEAD[3], CANSIM Table 380-0026
Investment in residential buildings in current dollars	1961 to most recent year	IEAD[3], CANSIM Table 380-0025
Paid rents for rental residential buildings and imputed rents for owner-occupied dwelling	1961 to most recent year	IEAD[3], CANSIM Table 380-0009

1. Investment and Capital Stock Division.
2. Industry Analysis Division.
3. Income and Expenditure Accounts Division.

Land–Land and inventory stocks are not calculated as an accumulation of past investments. In the past, the MFP programs assumed that there was little change in the real value of land in the business sector and estimated the real value of land at the industry level, based on the industry distribution of property taxes. We have now adopted the BLS methodology for estimating land stock in the MFP programs of Statistics Canada. The overall effect of adopting the BLS methodology on the business sector MFP growth is small.

The nominal value of land in the agriculture and non-farm business sectors is taken from the balance sheet for the sectors (Statistics Canada CANSIM Tables 002-0020 and 378-0004). The real value of land in those two sectors is taken from Hofmann, Filoso and Schofield (2005) which contains an estimate of total area of the dependable agriculture land for cultivation and total area of urban land.

Data on the value of land at the industry level are scarce. We assume that land stock is proportional to the structures stock. The land–structure ratios are derived from the corporate balance sheets by sector which provide data on book values of land and structures by industry for the 1972-to-1987 period (CANSIM Table 180-0002).

The real value of land at the industry level is estimated by deflating the nominal value of land using the structure capital's deflators. The final estimates of land stocks in both current and constant dollars at the industry level are benchmarked to the aggregate land stock in the total non-farm business sector.

Inventories–The data on inventory stock in current and constant dollars are obtained from three divisions of Statistics Canada: Industry Analysis Division (IAD), Agriculture Division, and Income and Expenditure Accounts Division (IEAD).

For the manufacturing industries, inventory stock in current and constant dollars are from IAD. These data are estimated from the Annual Survey of Manufacturers.

For the agriculture industries, inventory stock in current and constant dollars are from the Agriculture Division.

For the non-farm and non-manufacturing industries, inventory stock in current and constant dollars are from IEAD.

Capital service–Capital stock for each of 28 types of fixed reproducible assets, and land and inventories are aggregated into a measure of capital services, using implicit user costs of capital as weights. Statistics Canada adopts the endogenous rate of return specification for estimating the user cost of capital. The sum of the costs of capital of all assets exhausts the capital compensation (Baldwin and Gu 2007a, Harchoui and Tarkhani 2002). The source data for estimating the user costs of capital consist of capital compensation at the industry level and various tax parameters in the user cost specification.

Capital compensation is calculated as a residual that is equal to the difference between value-added in current dollars and labour compensation. Value-added in current dollars is obtained from the annual input–output tables. Total labour compensation consists of that going to paid workers and that going to self-employed workers. The labour compensation of paid workers is obtained from the Income and Expenditure Accounts. The labour compensation of self-employed workers is imputed. The labour compensation of self-employed workers is assumed to be proportional to that of paid workers with the same education, experience and industry (see the Methodology Section for details).

To obtain various tax parameters, we use the various sources that are documented in Harchaoui and Tarkhani (2002).

The nominal value of GDP and residual capital compensation are not available for the three years following the most recent input–output tables. As a result, the user cost of capital for each type of asset cannot be calculated using the endogenous rate of return specification that requires data on capital compensation. To combine capital stock for each type of asset to form capital-input estimates for those post input–output years, we assume that the real user cost of an asset is equal to the one in the most recent input–output reference year.[5]

4.3.4 Energy, material and service intermediate inputs

The measures of energy, materials and purchased services inputs in the industry KLEMS productivity program are obtained from the use matrices of the input–output accounts. For the purpose of estimating MFP, we value inputs at purchaser prices.

Energy input is obtained by chained-Fisher aggregation of various energy inputs. It represents the various fuels purchased for use as heat or power, including electricity, fuel oil, coal, natural gas and other miscellaneous fuels. Material input is obtained from chained-Fisher aggregation of various material inputs. It represents all commodity inputs exclusive of fuel (electricity, fuel oil, coal, natural gas and other miscellaneous fuels) but inclusive of fuel-type inputs used as raw materials in a manufacturing process, such as crude petroleum used by the refining industry. Services input is obtained from chained-Fisher aggregation of various services inputs. It consists of the following nine types: communications; finance and insurance; real estate rental; hotel services; repair services; business services, including equipment rental, engineering and technical services and advertising; vehicle repair; medical and educational services; and purchases from government enterprises.

5. Quality assurance and quality rating

For quality assurance, we examine the incidence and nature of breaks in the following series:

- price index of all the variables in both level and growth; and
- quantity index of all the variables in both level and growth.

In addition, we provide a number of comparisons between evidence in the MFP programs and evidence from other sources.

- Compare capital stock estimates in the MFP accounts with those of the investment and capital stock division (ICSD) of Statistics Canada. There are differences between the two estimates, but we expect the difference in the growth rates of two capital stock estimates should be small.
- Examine the sources of the revisions to output and inputs between the production cycles.

5. To estimate preliminary measures of capital services for the year when implicit user costs are not available, the BLS assumes that the asset shares of capital compensation are the same as in the previous year when such data are available (Meyer and Harper 2005).

- Compare our findings on productivity growth with those from other sources such as the OECD.

5.1 Quality rating of the industry productivity (KLEMS) database

The industry productivity database is derived from data associated with the National Accounts, which are constructed from a number of different sources. The input–output accounts reconcile different series so as to provide integrated, but balanced series. An evaluation of the 'quality' of the KLEMS data therefore requires professional judgment on the accuracy of both the underlying series and their coherency—the extent to which series are consistent with one another and are consistent over time.

Two sets of quality measures are provided here: 1) quality rating that is based on professional judgment and common sense; and 2) quality rating that is based on statistical detection of outliers. The first method has been used previously (Beckstead, Girard and Harchaoui 2001). The second method has been developed more recently by Macdonald (2007).

5.1.1 Evaluation based on judgment

Data from productivity programs are assessed for their statistical reliability and assigned a rating that indicates the level of confidence with which they may be used. The ratings are '1' for the most reliable data, '2' for fairly reliable, and '3' for less reliable but still acceptable. Tables A1 and A2 in the Appendix present the ratings of input costs in current dollars and Fisher volume indices of output, inputs and combined inputs at the L-level of industry aggregation based on NAICS.

The ratings in those two tables are based on three criteria: the quality of data sources including deflators; the nature of breaks in the series; and the volatility of the series. They are derived from the quality ratings that Beckstead, Girard and Harchaoui (2001) have developed for a KLEMS database based on SIC.[6]

5.1.2 Evaluation based on statistical inferences

Evaluations can also be made based on a more formal or rigorous set of rules. Macdonald (2007) has developed a set of rules that identify 'unusual' observations and then count the number of the unusual observations by industry.

The extent of irregular observations needs to be considered when evaluating data quality. These observations can arise from factors endogenous to the economic system, such as industry specific or aggregate demand and supply shocks or business-cycle turning points. They can also arise from factors that are exogenous to the economic system, such as measurement error and methodology changes. The KLEMS database is generated in part by the make-and-use tables,

6. Quality ratings of the volume indices of capital services differ from those in Beckstead, Girard and Harchaoui (2001) as the capital services estimates have gone through a major revision since then (Harchaoui and Tarkhani 2002, and Baldwin and Gu 2007b).

where construction involves the reconciliation of many data sources. Over time, industry and commodity classifications change and series have to be spliced. New sources of information (e.g., on prices) become available and have to be integrated within the tables. Despite great care being exercised to provide continuity in the series, some irregular or “aberrant” points exist that may cause the quality of the series to be less than ideal for some purposes.

Table A3 in the Appendix summarizes the rankings of data on value-added, capital input, labour input and multifactor productivity based on value-added in the KLEMS database at the L-level of aggregation. We have divided industries into three groups, according to the number of aberrant observations: “poor” industries with 11 to 14 irregular observations; “average” industries with 8 to 10 irregular observations, and “best” industries with 4 to 7 irregular observations.

6. Research

Statistics Canada maintains an active productivity research program (See Statistics Canada 2003 for description). The scope of the research program

- provides information on the course of productivity growth in Canada;
- provides Canada–United States comparisons;
- investigates the impact of productivity growth on overall economic growth in Canada;
- examines the underlying dynamics of plants in order to investigate the differences in sub-populations;
- provides the underpinnings for re-engineering the MFP program; and
- develops new experimental productivity estimates to help us understand eco-efficiency.

Here, we mention only two of many research projects that have been undertaken to improve the measurement of labour input, capital input and MFP growth.

6.1 Labour

The labour input measures in the MFP accounts is a weighted combination of hours worked and can be divided into hours and changes in labour composition. The change in the labour composition arising from the changes in the education, experience and employment categories (paid workers versus self-employed workers) is found to have been an important contributor to the labour productivity growth over the last 45 years in Canada.

To construct the labour composition estimates, we need estimates of labour compensation going to the self-employed workers. However, the labour compensation of self-employed workers is not available from the Canadian System of National Accounts (SNA). Instead, the Canadian SNA provides an estimate of mixed income or gross operating surplus that includes both labour and capital income of the self-employed worker.

The income of self-employed workers is therefore established by imputation. There is no international standard for imputing the labour compensation of self-employed workers. The MFP programs in different countries have adopted different practices for extracting the labour income of self-employed workers. Current research compares alternative methods for imputing the labour income of self-employed workers and examines the effects of the different methods on labour input and MFP growth estimates in Canada.

6.2 Capital

Capital input in the MFP programs of Statistics Canada encompasses the 28 types of fixed reproducible assets and land and inventories. It excludes R&D capital, intangible capital and infrastructure capital. Recent academic research suggests those capital assets are important contributors to economic and productivity growth. Current research in the area of capital input measurement includes

- estimating R&D capital stock and other forms of intangible assets and examining their contribution to economic and productivity growth; and
- examining the contribution of public infrastructure capital to economic and productivity growth.

7. Publications

The outputs of the MFP program of Statistics Canada are published in a number of different products. These include

- CANSIM Table 383-0021 for the major sector MFP measures and Table 383-0022 for industry KLEMS database;
- *The Canadian Productivity Review*. Catalogue no. 15-206 XIE;
- *Productivity Growth in Canada*. Catalogue no. 15-204 XPE; and
- The Canadian Productivity Accounts-Data, Catalogue no. 15-003 XIE.

Appendix

Table A1
Ratings of Fisher volume indices at the L level of aggregation

Table A2
Ratings of the inputs cost in current dollars at the L level of aggregation

Table A3
Ratings based on statistical detection of the number of aberrant observations at the L level of aggregation

Table A1
Ratings of Fisher volume indices at the L level of aggregation

No.	Industry	Capital (IFQK)	Labour (IFQL)	Energy (IFQE)	Material (IFQM)	Service (IFQS)	Gross output (IFQV)	Combined inputs (KLEMS)	MFP – gross (IFPV)	Value-added output (IFQA)	Combined inputs (KL)	MFP – value-added (IFPA)
001	Crop and animal production	1	1	2	2	1	2	2	2	2	1	2
002	Forestry and logging	2	1	2	2	2	1	2	2	1	2	2
003	Fishing, hunting and trapping	3	2	3	3	2	1	3	3	2	3	3
004	Support activities for agriculture and forestry	2	1	2	2	2	2	2	2	2	2	2
005	Oil and gas extraction	2	1	1	2	1	1	3	3	1	3	3
006	Coal mining	2	1	1	2	1	1	2	2	2	2	2
007	Metal ore mining	2	1	1	2	2	1	2	2	1	2	2
008	Non-metallic mineral mining and quarrying	2	1	1	2	1	1	2	2	1	2	2
009	Support activities for mining, oil and gas extraction	2	2	2	2	2	3	2	3	3	2	3
010	Electric power generation, transmission and distribution	1	1	3	2	2	1	1	1	1	1	1
011	Natural gas distribution, water and other systems	1	1	3	3	1	1	2	2	1	1	1
012	Construction	1	1	3	2	1	1	1	1	2	1	2
013	Animal food manufacturing	1	1	2	1	2	1	1	1	2	1	2
014	Sugar and confectionery product manufacturing	1	1	1	1	1	1	1	1	1	1	1
015	Fruit, vegetable preserving, specialty food manufacturing	2	1	1	1	1	1	1	1	1	2	2
016	Dairy product manufacturing	1	1	1	1	1	1	1	1	2	1	2
017	Meat product manufacturing	1	1	2	1	2	1	1	1	2	1	2
018	Seafood product preparation and packaging	1	1	2	1	1	1	1	1	1	1	1
019	Miscellaneous food manufacturing	2	1	1	1	1	1	1	1	2	2	2
020	Soft-drink and ice manufacturing	1	1	1	1	1	1	1	1	1	1	1
021	Breweries	1	1	1	1	1	1	1	1	1	1	1
022	Wineries	1	1	1	1	1	1	1	1	1	1	1
023	Distilleries	1	1	1	1	1	1	1	1	1	1	1
024	Tobacco manufacturing	2	1	1	1	1	1	1	1	1	2	2
025	Textile and textile product mills	1	1	1	1	1	1	1	1	1	1	1
026	Clothing manufacturing	1	1	1	1	1	1	1	1	1	1	1
027	Leather and allied product manufacturing	1	1	1	1	1	1	1	1	1	1	1
028	Wood product manufacturing	1	1	1	1	1	1	1	1	1	1	1
029	Pulp, paper and paperboard mills	1	1	1	1	1	1	1	1	1	1	1
030	Converted paper products manufacturing	1	1	1	1	1	1	1	1	1	1	1
031	Printing and related support activities	1	1	1	1	1	1	1	1	1	1	1

Table A1
Ratings of Fisher volume indices at the L level of aggregation (continued)

No.	Industry	Capital (IFQK)	Labour (IFQL)	Energy (IFQE)	Material (IFQM)	Service (IFQS)	Gross output (IFQV)	Combined inputs (KLEMS)	MFP – gross (IFPV)	Value-added output (IFQA)	Combined inputs (KL)	MFP – value-added (IFPA)
032	Petroleum and coal products manufacturing	2	2	3	1	1	1	1	1	2	2	2
033	Basic chemical manufacturing	2	1	1	1	1	1	1	1	1	2	2
034	Resin, synthetic rubber, artificial, synthetic fibres & filament	2	1	2	1	1	1	1	1	1	2	2
035	Pesticides, fertilizer ,other agricultural chemical mnfg	2	1	3	1	1	2	1	2	1	2	2
036	Pharmaceutical and medicine manufacturing	1	1	1	1	1	1	1	1	1	1	1
037	Miscellaneous chemical product manufacturing	2	2	2	1	1	1	1	1	1	2	2
038	Plastics product manufacturing	1	1	1	1	1	1	1	1	1	1	1
039	Rubber product manufacturing	1	1	1	1	1	1	1	1	1	1	1
040	Cement and concrete product manufacturing	2	1	1	1	1	1	1	2	2	2	2
041	Miscellaneous non-metallic mineral product manufacturing	1	1	2	1	1	1	1	1	1	1	1
042	Primary metal manufacturing	1	1	2	1	1	1	1	1	2	1	2
043	Fabricated metal product manufacturing	2	1	2	1	1	1	1	1	1	2	2
044	Machinery manufacturing	1	1	1	1	1	1	1	1	1	1	1
045	Computer and peripheral equipment manufacturing	2	2	3	2	1	2	2	2	2	2	2
046	Electronic product manufacturing	2	2	2	2	2	2	2	2	2	2	2
047	Household appliance manufacturing	2	1	1	1	2	1	1	1	2	2	2
048	Electrical equipment and component manufacturing	2	1	2	1	1	1	1	1	1	2	2
049	Motor vehicle manufacturing	1	1	2	1	1	1	1	1	1	1	1
050	Motor vehicle body and trailer manufacturing	1	1	1	1	1	1	1	1	1	1	1
051	Motor vehicle parts manufacturing	1	1	1	1	1	1	1	1	1	1	1
052	Aerospace product and parts manufacturing	1	1	2	1	1	1	1	1	1	1	1
053	Railroad rolling stock manufacturing	1	1	1	1	1	1	1	1	1	1	1
054	Ship and boat building	1	1	1	2	1	1	1	1	1	1	1
055	Other transportation equipment manufacturing	1	1	2	1	1	1	1	1	1	1	1
056	Furniture and related product manufacturing	1	1	1	1	1	1	1	1	1	1	1
057	Miscellaneous manufacturing	1	1	2	1	1	1	1	1	1	1	1
058	Wholesale trade	1	1	1	1	1	1	1	1	1	1	1
059	Retail trade	1	1	2	2	1	1	1	1	1	1	1
060	Air transportation	1	1	1	3	1	1	1	1	1	1	1
061	Rail transportation	1	1	2	3	2	1	1	1	1	1	1
062	Water transportation	1	1	2	3	2	1	2	2	1	1	1

Table A1
Ratings of Fisher volume indices at the L level of aggregation (concluded)

No.	Industry	Capital (IFQK)	Labour (IFQL)	Energy (IFQE)	Material (IFQM)	Service (IFQS)	Gross output (IFQV)	Combined inputs (KLEMS)	MFP – gross (IFPV)	Value-added output (IFQA)	Combined inputs (KL)	MFP – value-added (IFPA)
063	Truck transportation	1	1	1	1	1	1	1	1	1	1	1
064	Transit and ground passenger transportation	1	1	1	3	1	1	1	1	1	1	1
065	Pipeline transportation	2	2	3	3	2	1	2	2	1	2	2
066	Scenic and sightseeing transportation and support activities for transportation	1	1	1	3	1	1	1	1	1	1	1
067	Postal service and couriers and messengers	1	1	3	2	2	1	1	1	1	1	1
068	Warehousing and storage	1	1	2	3	2	1	2	2	2	1	2
069	Motion picture and sound recording industries	1	1	1	1	1	1	1	1	2	1	2
070	Broadcasting and telecommunications	1	1	2	2	1	1	1	1	1	1	1
071	Publishing industries, information services and data processing service	1	1	1	1	1	3	1	3	3	1	1
072	Monetary authorities and depository credit intermediation	2	1	1	3	1	3	2	3	3	2	3
073	Insurance carriers	2	1	3	2	1	1	1	1	2	2	2
074	Lessors of real estate	2	1	1	3	1	3	2	3	3	2	3
075	Rental and leasing services and lessors of non-financial intangible ass	2	1	1	3	1	3	2	3	3	2	3
076	Other finance, insurance, real estate and management of companies	2	1	2	3	1	2	2	2	3	2	3
077	Advertising and related services	1	1	1	1	1	3	1	3	3	1	3
078	Architectural, engineering, legal and accounting services	1	1	1	1	1	3	1	3	3	1	3
079	Other professional, scientific and technical services	1	1	1	1	1	3	1	3	3	1	3
080	Administrative and support services	1	1	1	1	1	3	1	3	3	1	3
081	Waste management and remediation services	1	1	1	1	1	3	1	3	3	1	3
082	Educational services (except universities)	1	1	2	2	1	3	1	3	3	1	3
083	Health care services (except hospitals), social assistance	1	1	1	3	1	3	1	3	3	1	3
084	Arts, entertainment and recreation	1	1	1	1	1	1	1	1	2	1	2
085	Accommodation and food services	1	1	2	1	1	3	1	3	3	1	3
086	Repair and maintenance	1	1	1	2	1	3	1	3	3	1	3
087	Grant-making, civic, professional and similar org.	1	1	3	1	2	1	2	2	1	1	1
088	Personal and laundry services and private households	1	1	1	2	1	3	1	3	3	1	3

Note: 1=most reliable; 2=fairly reliable; 3=less reliable.

Table A2
Ratings of current cost at the L level of aggregation

No.	Industry	Capital (PKK)	Labour (PLL)	Energy (PEE)	Material (PMM)	Service (PSS)
001	Crop and animal production	1	1	1	2	1
002	Forestry and logging	1	1	2	2	2
003	Fishing, hunting and trapping	1	1	2	2	1
004	Support activities for agriculture and forestry	1	1	2	2	2
005	Oil and gas extraction	1	1	1	1	1
006	Coal mining	3	1	1	1	1
007	Metal ore mining	1	1	1	1	1
008	Non-metallic mineral mining and quarrying	2	1	2	1	1
009	Support activities for mining and oil and gas extraction	2	1	1	1	1
010	Electric power generation, transmission and distribution	1	1	3	2	1
011	Natural gas distribution, water and other systems	1	1	3	3	1
012	Construction	1	1	2	1	1
013	Animal food manufacturing	2	1	2	1	1
014	Sugar and confectionery product manufacturing	2	1	1	1	1
015	Fruit and vegetable preserving and specialty food manufacturing	1	1	1	1	1
016	Dairy product manufacturing	2	1	1	1	1
017	Meat product manufacturing	2	1	2	1	1
018	Seafood product preparation and packaging	2	1	1	1	1
019	Miscellaneous food manufacturing	2	1	1	1	1
020	Soft-drink and ice manufacturing	1	1	1	1	2
021	Breweries	2	1	1	1	1
022	Wineries	1	1	1	1	1
023	Distilleries	1	1	2	1	1
024	Tobacco manufacturing	2	1	1	1	2
025	Textile and textile product mills	2	1	2	1	1
026	Clothing manufacturing	1	1	1	1	1
027	Leather and allied product manufacturing	3	1	1	1	1
028	Wood product manufacturing	3	1	2	1	1
029	Pulp, paper and paperboard mills	2	1	1	2	2
030	Converted paper products manufacturing	1	1	1	1	1
031	Printing and related support activities	1	1	1	1	1
032	Petroleum and coal products manufacturing	3	1	2	2	1
033	Basic chemical manufacturing	2	1	2	1	1
034	Resin, synthetic rubber, and artificial and synthetic fibres and filament	3	1	2	1	1
035	Pesticides, fertilizer and other agricultural chemical manufacturing	2	1	3	1	1
036	Pharmaceutical and medicine manufacturing	1	1	1	1	1
037	Miscellaneous chemical product manufacturing	1	1	1	1	1
038	Plastics product manufacturing	1	1	1	1	1
039	Rubber product manufacturing	3	1	1	1	1
040	Cement and concrete product manufacturing	2	1	1	1	1
041	Miscellaneous non-metallic mineral product manufacturing	2	1	2	1	1
042	Primary metal manufacturing	3	1	2	1	1
043	Fabricated metal product manufacturing	1	1	1	1	1
044	Machinery manufacturing	1	1	1	1	1
045	Computer and peripheral equipment manufacturing	3	1	1	2	1
046	Electronic product manufacturing	2	1	2	2	2
047	Household appliance manufacturing	3	1	1	1	1
048	Electrical equipment and component manufacturing	1	1	2	1	1

Table A2
Ratings of current cost at the L level of aggregation (concluded)

No.	Industry	Capital (PKK)	Labour (PLL)	Energy (PEE)	Material (PMM)	Service (PSS)
049	Motor vehicle manufacturing	3	1	1	1	2
050	Motor vehicle body and trailer manufacturing	3	1	1	1	1
051	Motor vehicle parts manufacturing	1	1	1	1	1
052	Aerospace product and parts manufacturing	3	1	1	1	1
053	Railroad rolling stock manufacturing	3	2	1	2	2
054	Ship and boat building	3	1	1	2	2
055	Other transportation equipment manufacturing	1	1	1	1	1
056	Furniture and related product manufacturing	2	1	1	1	1
057	Miscellaneous manufacturing	1	1	1	1	1
058	Wholesale trade	1	1	1	1	1
059	Retail trade	1	1	2	1	1
060	Air transportation	1	1	1	1	1
061	Rail transportation	1	1	2	1	1
062	Water transportation	1	1	2	1	1
063	Truck transportation	1	1	1	1	1
064	Transit and ground passenger transportation	1	1	1	1	2
065	Pipeline transportation	1	2	2	2	1
066	Scenic and sightseeing transportation and support activities for transportation	1	1	1	1	2
067	Postal service and couriers and messengers	3	1	3	1	1
068	Warehousing and storage	2	1	3	1	1
069	Motion picture and sound recording industries	1	1	1	1	1
070	Broadcasting and telecommunications	1	1	2	2	2
071	Publishing industries, information services and data processing service	1	1	1	2	1
072	Monetary authorities and depository credit intermediation	1	1	1	2	1
073	Insurance carriers	1	1	1	2	1
074	Lessors of real estate	1	1	1	2	1
075	Rental and leasing services and lessors of non-financial intangible ass	1	1	1	2	1
076	Other finance, insurance and real estate and management of companies	1	1	1	2	1
077	Advertising and related services	1	1	1	2	1
078	Architectural, engineering, legal and accounting services	1	1	1	2	1
079	Other professional, scientific and technical services	1	1	1	2	1
080	Administrative and support services	1	1	1	2	1
081	Waste management and remediation services	1	1	1	2	1
082	Educational services (except universities)	3	1	1	1	1
083	Health care services (except hospitals) and social assistance	1	1	1	2	1
084	Arts, entertainment and recreation	1	1	1	1	1
085	Accommodation and food services	1	1	1	1	1
086	Repair and maintenance	2	1	2	1	1
087	Grant-making, civic, and professional and similar organizations	1	1	2	1	2
088	Personal and laundry services and private households	2	1	2	1	1

Note: 1=most reliable; 2=fairly reliable; 3=less reliable.

Table A3
Ratings based on the number of aberrant observations, by industry

No.	Industry	Data quality
001	Coal mining	3
002	Pesticides, fertilizer and other agricultural chemical manufacturing	3
003	Miscellaneous chemical product manufacturing	3
004	Grant-making, civic, and professional and similar organizations	3
005	Oil and gas extraction	3
006	Clothing manufacturing	3
007	Other finance, insurance and real estate and management of companies	3
008	Educational services (except universities)	3
009	Arts, entertainment and recreation	3
010	Forestry and logging	3
011	Support activities for agriculture and forestry	3
012	Animal food manufacturing	3
013	Sugar and confectionery product manufacturing	3
014	Distilleries	3
015	Resin, synthetic rubber, and artificial and synthetic fibres and filament	3
016	Cement and concrete product manufacturing	3
017	Computer and peripheral equipment manufacturing	3
018	Motor vehicle body and trailer manufacturing	3
019	Miscellaneous manufacturing	3
020	Truck transportation	3
021	Scenic and sightseeing transportation and support activities for transportation	3
022	Postal service and couriers and messengers	3
023	Motion picture and sound recording industries	3
024	Fishing, hunting and trapping	3
025	Primary metal manufacturing	3
026	Fabricated metal product manufacturing	3
027	Aerospace product and parts manufacturing	3
028	Ship and boat building	3
029	Other transportation equipment manufacturing	3
030	Transit and ground passenger transportation	3
031	Pipeline transportation	3
032	Health care services (except hospitals) and social assistance	3
033	Natural gas distribution, water and other systems	2
034	Construction	2
035	Tobacco manufacturing	2
036	Textile and textile product mills	2
037	Lessors of real estate	2
038	Other professional, scientific and technical services	2
039	Administrative and support services	2
040	Personal and laundry services and private households	2
041	Metal ore mining	2
042	Meat product manufacturing	2
043	Miscellaneous food manufacturing	2
044	Leather and allied product manufacturing	2
045	Wood product manufacturing	2
046	Converted paper products manufacturing	2
047	Rubber product manufacturing	2
048	Miscellaneous non-metallic mineral product manufacturing	2

Table A3
Ratings based on the number of aberrant observations, by industry (concluded)

No.	Industry	Data quality
049	Motor vehicle manufacturing	2
050	Publishing industries, information services and data processing service	2
051	Monetary authorities and depository credit intermediation	2
052	Accommodation and food services	2
053	Repair and maintenance	2
054	Non-business sector	2
055	Non-metallic mineral mining and quarrying	2
056	Breweries	2
057	Pulp, paper and paperboard mills	2
058	Machinery manufacturing	2
059	Water transportation	2
060	Advertising and related services	2
061	Waste management and remediation services	2
062	Petroleum and coal products manufacturing	1
063	Electronic product manufacturing	1
064	Household appliance manufacturing	1
065	Electrical equipment and component manufacturing	1
066	Motor vehicle parts manufacturing	1
067	Furniture and related product manufacturing	1
068	Wholesale trade	1
069	Rail transportation	1
070	Warehousing and storage	1
071	Electric power generation, transmission and distribution	1
072	Seafood product preparation and packaging	1
073	Soft-drink and ice manufacturing	1
074	Wineries	1
075	Printing and related support activities	1
076	Pharmaceutical and medicine manufacturing	1
077	Railroad rolling stock manufacturing	1
078	Rental and leasing services and lessors of non-financial intangible ass	1
079	Architectural, engineering, legal and accounting services	1
080	Dairy product manufacturing	1
081	Basic chemical manufacturing	1
082	Plastics product manufacturing	1
083	Broadcasting and telecommunications	1
084	Insurance carriers	1
085	Crop and animal production	1
086	Support activities for mining and oil and gas extraction	1
087	Fruit and vegetable preserving and specialty food manufacturing	1
088	Retail trade	1
089	Air transportation	1

Note: 1=most reliable; 2=fairly reliable; 3=less reliable.

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