The Integration of the Canadian Productivity Accounts within the System of National Accounts

Current Status and Challenges Ahead

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March 2004

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I. Introduction

Statistical agencies succeed when public debate moves beyond arguments over the value that should be attached to a statistic to discussions about what the value of the statistic implies for policy purposes. If the political system has to worry about whether productivity growth is just 0.5% or as high as 4.0%, it is less likely to decide what policy challenges the level of productivity growth poses.

Productivity measures are often used as key economic indicators for evaluating relative performance across industries, across countries and over time. Unfortunately, debates about productivity all too often revolve around what the growth in productivity actually is. Part of this problem arises because some statistical systems produce conflicting estimates of productivity growth. Integrated systems of National Accounts reduce these problems. This paper describes how the integration of the Canadian Productivity Accounts (CPA) into the Canadian System of National Accounts (CSNA) is used to provide a coherent and consistent set of productivity estimates.

The publication of productivity measures is an important activity of the Canadian Productivity Accounts (CPA). Statistics Canada's productivity program has evolved over the years, stimulated by changes in data availability, by new developments in the economics literature, by the needs of data users and by the increase in the profile of the economy's productivity performance in Canadian public policy circles.

Following the development of the Canadian System of National Accounts (CSNA) after the Second World War, Statistics Canada introduced labour productivity measures for the aggregate business sector and its major constituent subsectors.[1] In recent years, the CPA have added multifactor productivity growth measures, which consider the productivity of a bundle of inputs (labour, capital, and purchased goods and services[2]), for the business sector and its constituent sub-sectors and industries to meet the demands of the user community.

The conceptual framework of the CPA corresponds closely to the standards set out in the OECD Productivity Manual (OECD 2001). The concepts and definitions used in the CPA generally conform to the standards set out in the 1993 System of National Accounts (1993 SNA) (United Nations 1993) and OECD (2001)—though some minor variations

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1 The definition of business sector used for productivity measures excludes all non-commercial activities as well as the rental value of owner-occupied dwellings. Corresponding exclusions are also made to the inputs. Business gross domestic product (GDP) as defined by the productivity program, represents 71% of the economy GDP in 1992. The business sector is split into the following major sub-sectors: goods-producing, services and manufacturing. The goods-producing sub-sector consists of agriculture, fishing, forestry, mining, manufacturing, construction and public utilities. Services comprise transportation and storage, communications, wholesale and retail trade, finance, insurance and real estate, and the group of community, business and personal services.

2 Purchased goods and services are known as intermediate inputs in the CSNA.

have been adopted to allow for particular Canadian data supply conditions or user requirements.[3]

This paper discusses the extent to which the CPA are integrated into the CSNA, with emphasis on the benefits and the challenges that are associated with the integration. By way of background, we first review the status of the integration and how the approach adopted by the CPA embodies internationally recommended standard practices for productivity measurement laid out in OECD (2001). The approach highlights how industry models of production and the production possibility frontier at the aggregate are employed using a consistent set of outputs and inputs available from the CSNA and the CPA. The paper then continues with a discussion on the benefits of the integration and the possible extensions.

II. The Current Structure of the Integration

1. Overview

Measures of productivity are derived by comparing outputs and inputs. The System of National Accounts provide a useful framework for organizing the information required for comparisons of this type. Integrated systems of economic accounts provide coherent, consistent alternate estimates of the various concepts that can be used to measure productivity.

Statistical systems that provide measures of productivity that are not compatible one with another tend to subtract from rather enhance the coherency of public debate. On occasion differences in productivity values are the result of the use of alternate formulae. Alternate methods of measuring productivity are quite legitimate. Economists have long drawn attention to the limitations inherent in a unique measure of productivity performance. In comparing alternative states of an economy, it is difficult to summarize all the relevant information in a single measure. Output is important, but the composition of the output—by end use, industry, and so on—is equally important in evaluating performance, interpreting economic events, and assessing the accuracy and consistency of the data.

Nevertheless, not all of the different estimates of productivity that the profession has provided to the public arena are just the result of different methodologies. Some come from the use of alternate measures of output that are not reconciled or inputs that do not conform to SNA standards. In a well-integrated system of National Accounts, the alternate measures of output (or inputs) used in productivity estimates should be equal to one another.

A complete economic system, as the accompanying paper on the *Architecture of the National Accounts* explains, consists of a set of integrated economic accounts, a system

[3] See Wilson (2004).

of supply and use tables of goods and services, financial accounts, and functional accounts—along with additional data on employment and population.

Productivity estimates rely on several different components of the complete set of accounts. The foundation of the CPA consists of the production account for the Canadian economy and a consolidated income and expenditure account.

The production account incorporates data on outputs and the intermediate consumption of goods. The production account captures the value of output and the value of intermediate inputs for each sector, and when the latter is subtracted from the former produces value added. Value added, when summed across all sectors, is equal to the gross domestic product of the economy.

The second important component is the consolidated income and expenditure accounts. The income account captures income accruing to the primary inputs—labour and capital—in the form of wages, salary, supplementary income and gross operating surplus. The expenditure accounts captures expenditures on commodities.

Integral to the production account and the expenditure accounts is the Supply and Use of Goods and Services framework that traces the production of commodities by industries through their use as intermediate inputs or final demand through to institutional sectors. The latter not only allows for the production of detailed industry input output tables but are the foundation of the calculation of GDP using final expenditures-consumption, investment, government and net exports.

There are three different ways in which the GDP aggregate can be derived from this system—the sum of value added, the sum of factor incomes and the sum of final expenditures. Consistency is imposed on the system with a series of identities. A system with imposed consistency will produce similar estimates of GDP for productivity estimates.

For the production system, the fundamental identity requires that the value of output be set equal to the value of factor inputs. Changes in values of product and factor inputs are separated into price and quantity components. Summary statistics measuring productivity can be derived either by comparing the ratio of real output to real factor input or the ratio of the price of output to the price of inputs.

For the consolidated income and expenditure accounts, the fundamental accounting identity requires that the value of consumer income be set equal to consumer outlays plus capital formation. Consumer income, consumer outlays, and capital formation are separated into price and quantity components. A summary measure of performance here that is related to the standard of living, can be derived from the ratio of real expenditures to real receipts or the ratio of the price of factor services to the price of expenditures.

The interpretation of real product, real factor input, and multifactor productivity make use of the notion of production possibility frontier possibility at the aggregate level. In each period the inputs may include reproducible durable assets of various ages, land, inventories, as well as services of labour. The outputs include durable goods, inventories, and goods and services for private and public consumption. Industry level data, which are based on the notion of a production unit, allow us to trace the sources of economic growth to their industry origins, to isolate and analyze the production structure of various segments of the economy, and to assess the relative importance of productivity growth, factor accumulation at both the industry and aggregate levels.

2. An Accounting View of the Integration

This section describes, in a more formal way, how the productivity accounts make use of the relationship between the industry and aggregate accounts in the CSNA.

The System of National Accounts

The CPA rely on the concept of a production function for each industry j with gross output (Y) expressed as a function of capital (K), labour (L), intermediate inputs (M) and the level of technology (T), that is

$$Y_j = f(K_j, L_j, M_j, T).$$

Under the assumption of constant returns to scale and competitive markets, the value of output is equal to the value of all inputs:

$$P_{Y,j}Y_j = P_{K,j}K_j + P_{L,j}L_j + P_jX_j.$$

We require the concept of industry value added in order to aggregate across sectors, and to provide an unduplicated measure of industry output.

Assuming that the production function is separable in intermediate input and value added, we define *value added* V_j implicitly from the equation:

$$\Delta \ell n Y_j = (1 - v_{V,j})\Delta \ell n X_j + v_{V,j}\Delta \ell n V_j,$$

where the weights are shares of value added in the value of gross output and value added in nominal terms is:

$$P_{V,j}V_j = P_{K,j}K_j + P_{L,j}L_j.$$

In the CSNA, the value of outputs and intermediate inputs that are needed to calculate valued added are available from a time series of inter-industry transactions tables. These tables consist of 1) a Use Table that allocates the output of each commodity among intermediate inputs and final demand categories and 2) a Make Table that allocates the use of each commodity among the industries that produce it. The output of a given commodity that is produced by all industries and the input of this commodity for all industries are equal in this system as a result of balancing.

In the Use Table, the j th column represents industry j, and the i th row represents commodity i. In nominal terms, the sum of the elements in column j is the value of the industry's output. This is equal to the value of this output to the producer, plus taxes paid on this output by the purchaser T_j:

$$P_{YT,j}Y_j = P_{Y,j}Y_j + T_j$$
$$P_{Y,j}Y_j = P_{K,j}K_j + P_{L,j}L_j + \sum_i P_{ij}^X X_{i,j}$$

where the price received by the seller is $P_{Y,j}$ and the price paid by the purchaser is $P_{YT,j}$. The values of capital and labour inputs, $P_{K,j}K_j$ and $P_{L,j}L_j$, are discussed in the following sections.

An industry may produce several commodities, and a commodity may be produced by several industries. The value of the output of industry j is equal to the value of all the commodities it produces:

$$P_{YT,j}Y_j = \sum_i M_{j,i},$$

where $M_{j,i}$ is the value of commodity i produced by j. This implies that:

$$VC_i = P_{YC,i}YC_i = \sum_j M_{j,i},$$

where YC_i denotes the quantity of domestically produced commodity i and VC_i the value.

The Make Table also includes sales to final demand. This is broken down into the familiar categories of personal consumption expenditures, gross private domestic investment, government purchases, exports, and imports:

$$F_i = c_i + i_i + g_i + x_i - m_i,$$

where the sum of the elements in row i of the Make Table is the value of all deliveries of the i'th commodity to intermediate and final demand.

Thus, the supply-demand balance for commodity *i* in value terms is:

$$P_{YC,i}YC_i = \sum_i P_i^X X_{i,j} + P_i^X F_i.$$

We can rewrite this as the total supply from domestic suppliers and imports, which equals total demand:

$$P_{YC,i}YC_i + P_{m,i}m_i = \sum_i P_i^X X_{i,j} + P_i^X (c_i + i_i + g_i + x_i).$$

Systems of national accounts that comply with this inter-industry accounting system provide alternate but equivalent measures of output that can be used in the estimation of productivity. But it is important to note that fully integrated systems need to fulfill these identities both in current and constant dollars—and the latter is sometimes missing from what are otherwise described as integrated National Accounts systems—see Appendix A.

The Canadian Productivity Accounts

The CPA produce several productivity measures for the aggregate business sector. Annual labour productivity for the Canadian business sector was the first measure of productivity introduced by Statistics Canada in the early sixties. More recently, quarterly labour productivity estimates for the business sector have been introduced to provide a more timely productivity estimates of performance.[4] For this measures output is measured as real GDP—deliveries in constant chained dollars of final goods and services by the business sector industries to domestic households, investment, government and non-profit institutions, and net exports—and is compared to labour input, measured as hours worked.

In addition, a multifactor productivity measure has been developed for the business sector, in recognition of the role that capital growth plays in output growth. As is the case for the labour productivity measure calculated for the aggregate business sector, output is measured as final demand GDP, but the input measure is an aggregate of hours worked adjusted for compositional changes in the workforce and capital services flows.

For both these aggregate business-sector measures, aggregate output F_t consists of investment goods I_t, consumption goods C_t and net exports N_t. These outputs are produced from aggregate input X_t, consisting of capital services K_t and labour services L_t. We represent productivity as a "Hicks-neutral" augmentation A_t of aggregate input:

$$F(C_t, I_t, N_t) = A_t \cdot X(K_t, L_t)$$

The outputs of investment, consumption goods and net exports and the inputs of capital and labour services are themselves aggregates, each with many sub-components. Under the assumptions of competitive product and factor markets, and constant returns to scale, growth accounting gives the share-weighted growth of outputs as the sum of the share weighted growth of inputs and growth in multifactor productivity:

$$\overline{w}_{C,t}\Delta \ell n C_t + \overline{w}_{I,t}\Delta \ell n I_t + \overline{w}_{N,t}\Delta \ell n N_t = \overline{v}_{K,t}\Delta \ell n K_t + \overline{v}_{L,t}\Delta \ell n L_t + \Delta \ell n A_t,$$

where $\overline{w}_{C,t}$ is consumption average share of nominal output, $\overline{w}_{I,t}$ is investment's average share of nominal output, $\overline{w}_{N,t}$ is net exports', $\overline{v}_{K,t}$ is capital's average share of nominal income, $\overline{v}_{L,t}$ is labour's average share of nominal income, Δ refers to a first difference,

[4] Quarterly estimates for 2-digit level industries have just been introduced.

and $\overline{w}_{C,t} + \overline{w}_{I,t} + \overline{w}_{N,t} = \overline{v}_{K,t} + \overline{v}_{L,t} = 1$. Note that we reserve the term *multi factor productivity* for the augmentation factor in the first equation .[5] The second equation enables us to identify the contributions of outputs as well as inputs to economic growth.

In addition to the aggregate business-sector productivity measures, the CPA produce a comprehensive set of industry productivity measures that are based on the input-output tables (IOT) and that enable users to trace aggregate productivity growth to its source in individual industries.[6] The output measures generated by the IOT are reconciled at the aggregate level with those produced by Statistics Canada's Income and Expenditures Accounts on final demand. The labour productivity estimates are produced at various levels of detail provided by the input/output tables for business or commercial industries—the L (167 industries), M (58 industries), and S (21 industries) level.[7] The multifactor productivity estimates are produced at the P (123 industries), M (58 industries) and S (21 industries) levels.[8]

Labour productivity measures are produced for real value added per hour worked. Three separate measures of multifactor productivity measures are produced, using different measures of output (gross output, valued added and sectoral output). These measures are a) real value added per unit of capital and labour inputs; b) gross output per combined unit of capital, labour and intermediate inputs; and c) sectoral output[9] per combined unit of capital, labour and sector intermediate inputs.

Domar's (1961) approach is utilized to link industry level productivity growth with aggregate multifactor productivity growth.

3. Integration of the Data

The CPA are an integral part of the Canadian System of National Accounts, particularly, the Input/Output tables (IOT) and the Income and Expenditures Accounts (IEA). Productivity measurement requires information on prices and quantities of the flow of commodities produced and purchased by various industries of the economy, the purchase of durable goods by categories of final demand and the compensation of primary inputs, all of which are available on a consistent basis from the CSNA. The Productivity Accounts makes use of the data on GDP from final expenditures and the input/output tables that are consistent with one another and then creates a matched database for labour and capital inputs that is integrated with the remainder of the data to create a master industry database—KLEMS—that can be used for analytical purposes.

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5 Preferring the term multifactor to total factor productivity.
6 These are produced with a two-year lag because the detailed input/output tables come out only with a lag.
7 These industry numbers apply to the SIC classification system. NAICS is slightly different.
8 The finest level of industry detail for multifactor productivity estimates is less than for labour productivity because investment data are not available for the L level.
9 This is the measure used by the BLS.

Output

The aggregate output data that are used for business-sector productivity estimates are based on the final demand GDP from Statistics Canada's quarterly Income and Expenditures Accounts.[10] The output concept is similar to the one used in the Bureau of Labor Statistics (BLS) for its productivity estimate of the aggregated business sector. Like the BLS, the CPA exclude the government sector and owner-occupied dwellings. The consumption of durable goods is measured in terms of personal expenditures and not as the service flows from consumers' durables and owner-occupied housing. Jorgenson and his associates also make use of the final demand approach at the aggregate level, but include general government, owner occupied dwellings and measure the flow of services of consumer durables.

A century of cooperation between the statistical agencies in Canada and the United States has served to produce comparable income and expenditure accounts, upon which both Canada and the U.S. base their aggregate productivity measures. [11]

Canada also produces a set of industry based productivity measures for its industry estimates and that can be used to build productivity estimates from the bottom up. Measurement of productivity at the industry level by the CPA requires information on prices and quantities available from a complete set of Input-Output Tables (IOT). This set of accounts is valuable for several reasons. First, they benchmark all the rest of the accounts, including the final demand GDP employed for aggregate productivity measures. As such, the CPA's estimates at the industry level are consistent with those at the more aggregate level. Second, considerable time and effort is spent in checking the concordance of industry-level measures of outputs and inputs and in valuing outputs and inputs consistently. Since the input/output production accounts are at the core of the statistical system, it provides an audit tool that permits the statistical system to monitor the various sources that are used in different parts of the process that builds data on expenditure, on factor income and on commodity production and use.

The IOT provide data in constant chained dollars and current prices for gross output, intermediate inputs and value added. In accordance with the SNA 1993, the receipts accruing to primary inputs consist of the following variables: a) wages and salaries, b) supplementary labour income; c) mixed income and d) other operating surplus and e) net indirect tax on production. Net indirect taxes on production include mostly property taxes and is included in the measurement of capital income. Wages and salaries and supplementary labour income measure the compensation of paid workers. Other

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[10] Alternately, the date could be taken from the GDP estimates that are produced by the Industry Measures Division that are used for the monthly GDP program, since the two measures are reconciled annually. But the expenditure accounts are revised earlier each year and are therefore chosen for the quarterly productivity program.

[11] Recent work that implemented this approach includes Jorgenson and Stiroh (2000), Jorgenson (2001) for the U.S. economy; and Jorgenson and Yip (2001) and Dougherty and Jorgenson (1997) for international comparisons, and Harchaoui and Tarkhani (2004a) and Harchaoui et al. (2004) for a Canada-U.S. comparison of economic growth and productivity performance.

operating surplus is essentially the gross capital income of incorporated businesses. Mixed income constitutes the earnings of both capital and labour inputs arising from the unincorporated portion of the business sector.

In accordance with SNA recommendations, output measures are valued at basic prices, *i.e.*, excluding net taxes on products whereas inputs are valued at purchaser's prices, *i.e.*, including net taxes on products as well as trade and transport margins.

The CPA's task on the production side is straightforward, since it makes use of a system of production accounts that is already integrated and reconciled. Progress has been made here in moving both the CNSA and CPA to similar concepts.[12] When it comes to constructing indices of input usage, the CPA's task is to integrate data from other parts of the statistical system—first for labour and then for capital.

Labour

The CPA are responsible for constructing labour estimates from various sources that accord with the recommendations of SNA (93) and that are consistent with the data that are produced by the production accounts. Other sources are available within Statistics Canada on employment that do not completely satisfy the requirements of the SNA. And none of these sources are reconciled to events that are occurring at the industry level in terms of output changes or income receipts. The CPA produce a set of labour estimates to accomplish both objectives.

Estimates of jobs and hours-worked are produced at a detailed industry level and by class of workers (see Maynard 2003). These estimates have recently been extended to all provinces and territories. Hours worked is the base measure used for productivity estimates because it represents a better measure of labour input than employment. The hours-worked measure captures changes in overtime worked, standard weekly hours, leave taken, and changes in the proportion of part-time employees.

Data on hours and number of jobs by province and territory and by industry are obtained from a number of different sources—both household and business surveys. The primary benchmark is a household-based survey—the Labour Force Survey (LFS). LFS employment series, which are based on the notion of persons employed, are adjusted to the SNA concept of jobs by adding multiple job holders and excluding those persons absent from work with pay during the reference week. While the LFS is felt to provide the most accurate benchmark for the total economy and for major industry groupings, other sources (employer-based surveys) are felt to provide a better split of employment across detailed industries because firms are more accurately assigned to industries than are households.[13] Therefore, a number of other sources are used to split estimates of labour inputs at the aggregate level into detailed industry estimates.

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[12] For example, both now use the same definition of the business sector, and both use both Fisher indices and the concept of basic prices to define gross domestic product.

[13] Another disadvantage of firm-based surveys is that they do not easily produce data on the number of persons employed—they are only producing jobs. Household surveys also directly measure number of

The CPA then construct hours-worked in a way that is consistent with the SNA 1993. Statistics on hours worked that are calculated for Statistics Canada's productivity program include:

a) hours actually worked during normal periods of work;

b) time worked in addition to hours worked during normal periods of work, and generally paid at higher rates than the normal rate (overtime);

c) time spent at the place of work on work such as the preparation of the workplace, repairs and maintenance, preparation and cleaning of tools, and the preparation of receipts, time sheets and reports;

d) time spent at the place of work waiting or standing-by for such reasons as lack of supply of work, breakdown of machinery, or accidents, or time spent at the place of work during which no work is done but for which payment is made under a guaranteed employment contract; and

e) time corresponding to short periods of rest at the workplace, including tea and coffee breaks.

Statistics of hours actually worked exclude:

a) hours paid for but not actually worked, such as paid annual leave, paid public holidays, paid sick leave;

b) meal breaks; and time spent on travel to and from home and work

Productivity measures need to capture hours worked and not hours paid if they are to accurately represent effort. Both employer and household surveys have potential problems with capturing data on hours worked. Firm-based employer surveys typically collect data on hours paid (or standard hours paid), rather than hours worked. Records of hours paid are the usual measure that employers keep in their management information systems and that therefore can be collected from an employer survey. Hours paid includes hours not worked because of vacation, illness, holiday, etc., and excludes hours worked but not paid (e.g. unpaid overtime). While a correction can be made to hours-paid, as measured in employer surveys, to derive hours-worked using a supplementary employer survey (as is done in the U.S.), this adds an additional possibility of error that has become more important in the last two decades.

In contrast, a well designed household survey can ask the respondent directly for hours paid—and with a well crafted set of questions, household surveys at least focus directly on the concept that is required for productivity purposes. Employer surveys are not able to do this. Furthermore, even if this was attempted in an employer survey, the employer

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people employed and when they ask questions about whether an individual holds multiple jobs, they can provide measures of jobs as well.

would be highly unlikely to be able to report the unpaid overtime of employees that need to be included in the hours-worked estimate for productivity measures. For this reason, the CPA use our household labour survey to develop data on average hours worked by job. Total hours worked are then created by multiplying jobs by hours worked per job.

Changes in the skill level of the labour force are not captured in a simple sum of hours worked across all workers. To obtain a measure of productivity that excludes the effect of changing skill levels, the CPA adjust hours worked for changes in the quality or composition of the labour force.

Our primary data source for the derivation of hours adjusted for changes in composition are the quinquennial Censuses of Population, the CPA, and the annual LFS surveys. The CPA provide totals for hours worked and the Census and LFS together allows us to estimate the growth in labor 'quality'.

Details on the construction of the labour data can be found in Gu et al. (2003). Briefly, the Censuses of Population provide detailed data on employment, hours, and labour compensation across demographic groups in census years. The annual LFS data are used to interpolate similar data for intervening years and the CPA data provide control totals.

The demographic groups include 112 different types of workers, cross-classified by class of workers (employee, self-employed or unpaid), age (15-17, 18-24, 25-34, 35-44, 45-54, 55-64, 65+), and education (0-8 years grade school, 1-3 years high school, 4 years high school, 1-3 years college, 4 years college, 5+ years college). Adjustments to the data include allocations of multiple job-holders and an estimation procedure to recover bridging to maintain consistent definitions of demographic groups over time. These detailed data cover 1961 to 2000 and allows us to estimate the quality of labour input for the private business sector as well as for individual industries down to the 3-digit (L) level.

The CPA's task in creating the labour input numbers is twofold. On the one hand, it is responsible for creating data that meet the conceptual challenges outline above. But it also is responsible for integrating these data into the supply and use system—by generating hours-worked by cell that accord with the rest of the data is being generated by the SNA. This requires numerous consistency checks that involve comparison of labour trends against known events—shutdowns due to strikes, or blackouts; new plant and firm openings etc. It also involves constant comparisons against other variables—perhaps the most important of which is labour remuneration that is being produced within the SNA. For labour income divided by hours worked produces estimates of hourly remuneration that should accord with other exogenous information on wage rates if the system is to be fully coherent within itself and with outside information.

Capital Services

The CPA are also responsible for developing internally consistent, coherent estimates of capital services. Here, the CPA rely on investment data first from the Income and

Expenditures Accounts for final demand GDP and then from Input/Output accounts that are built from industry survey data obtained from the Investment and Capital Stock Division. The latter acquire investment expenditures from an establishment survey that provides industry-level data—that at the total economy level are reconciled with the commodity information on investment that is collected for the expenditure accounts.

At the business-sector level, the CPA employ investment series by asset classes that are available from final demand GDP; productivity estimates for major industry groupings are based on investment series by industry and asset classes that are included with the production accounts of the input/output tables. Because of the consistency checks that are present within the National Accounts, the investment estimates obtained from commodity data for final demand are basically the same as those derived from the production accounts.

The CPA measure the flow of capital services at the aggregate business-sector level and at the industry level. As with the estimates of labour, the CPA first develop overall capital input data that treats all assets similarly, but then accounts for differences among assets with different marginal products.[14]

The CPA begin with investment data from Statistics Canada's quarterly Income and Expenditures Accounts, estimate capital stocks using the perpetual inventory method, and aggregate capital stocks using rental prices as weights. This approach, originated by Jorgenson and Griliches (1967), is based on the identification of rental prices with marginal products of different types of capital. Our estimates of these prices incorporate differences in asset prices, service lives and depreciation rates, and the tax treatment of capital incomes. A broad definition of capital is employed, which includes tangible assets such as equipment and structures, as well as land, and inventories. A service flow is then estimated from the installed capital stock.

In order to estimate productivity at the aggregate business sector, the CPA use an aggregate production function approach and require an aggregate measure of capital services $K_t = \phi(K_{1t}, K_{2t}, ..., K_{Mt})$, where M includes all types of reproducible fixed assets, inventories, and land. For the industry level estimates, a similar notion of capital services is developed for each industry i, that is, $K_{it} = \varphi(K_{i1t}, K_{i2t}, ..., K_{iMt})$. The CPA employ quantity indexes to generate aggregate capital services, capital stock, and investment series. The growth rate of aggregate capital services is defined as a share-weighted average of the growth rate of the components, where the weights are the value share of capital income.

The primary data source for estimating the aggregate flow of capital services is the investment series by asset classes available from the final demand matrix of the IOT for the benchmark years and updated for more recent years by the investment series available from the quarterly Income and Expenditures Accounts.

[14] See Harchaoui and Tarkhani (2003a) for methodology.

The Final Demand Matrix of the IOT contains current price and chain-type quantity indices for 476 types of commodities from 1961 to 2000. Table 1 shows our reclassification of these data into 22 non-residential asset classes. In addition, other sources yield data on 4 residential assets.

Table 1. Classification of Total Capital by Asset Classes

Computers & Office Equipment
Communication Equipment
Software-Own Account
Software-Pre-Packaged
Software-Custom Design
Office furniture, Furnishing
Household and Services Machinery and Equipment
Electrical Industrial Machinery and Equipment
Non-Electrical Industrial Machinery and Equipment
Industrial Containers
Conveyors & Industrial trucks
Automobiles & Buses
Trucks (Excluding Industrial Trucks) & Trailers
Locomotives, Ships & Boats & Major Replacement Parts
Aircraft, Aircraft Engines & Other Major Replacement Parts
Other Equipment
Non-Residential Building Construction
Road, Highway & Airport Runway Construction
Gas & Oil Facility Construction
Electric Power, Dams & Irrigation Construction
Railway & Telecommunications Construction
Other Engineering Construction
Cottages
Mobiles
Multiples
Singles
Inventories
Land

The underlying investment data from the IOT runs only through the 'reference' year—the year for which the first set of input/output accounts have been produced. This is two years from the current period. The CPA make several adjustments to extend the investment series through to the most current year and to make the investment series by industry consistent with those of national accounts. The investment series is extended through to the present based on the quarterly Income and Expenditures Accounts. The total value of investment in major categories – structures, equipment and software, residential structures is set equal to the corresponding total derived from the Income and Expenditures aggregates.

These procedures generated a complete time series of investment in 28 private assets (18 types of equipment and software, 6 types of non-residential structures, and 4 types of residential structures) for about 100 industries. Capital stocks were then estimated using the perpetual inventory method and a geometric depreciation rate based on age-price profiles developed by Gellatly et al (2003). Important exceptions are the depreciation rates for assets in the structures category. Owing to a lack of an active transaction market for structures, depreciation rates were derived from the existing information on length of lives from a survey done by the Investment and Capital Stock Division that produces expected length of life by asset type.

We also assemble data on investment and land to complete our capital estimates. The inventory data come primarily from the Income and Expenditures Accounts in the form of farm and non-farm inventories. Inventories are assumed to have a depreciation rate of zero and do not face an investment tax credit or capital consumption allowance, so the rental price formula is a simplified version of the one employed for reproducible assets. Data on land are obtained from the Canadian Balance Sheet Accounts in current prices and in volume from the Environment Accounts. Like inventories, depreciation, the investment tax credit, and capital consumption allowances for land are taken to be zero.

Capital inputs at the industry level are determined in three main steps. First, a detailed array of capital stocks is developed for various asset types in different industries. This data comes from the input/output accounts that lists the investment types by industry—based on information that is attained by an industry survey of investment that is done by the Investment and Capital Stock Division. The data that are obtained by this survey are reconciled at the aggregate level with the commodity data that go into the final demand of the expenditures estimate of GDP. But here the CPA perform time-series consistency checks to reduce inconsistencies—once again using the same criteria used in the case of labour estimates. They ask such questions as: Do discontinuities exist when major new projects are brought on line? Is there output where investment takes place? Are changes the result of classification changes?

The investment flows that are available from the input/output tables are only created at a relatively high level of industry aggregation. The CPA therefore take the investment flows from the Investment and Capital Stock Division and uses these to derive more detailed industry flows for the finest level of industry detail—following much the same procedure as is done for the labour data where the household data is used for aggregate benchmarks and then spread at finer levels of industry detail using other sources of information.

Once the investment flows are edited for consistency, asset-type capital stocks are aggregated for each industry to measure capital input for the industry; and industry capital inputs are aggregated to measure sectoral level capital input. The end result is an estimate of capital services at the industry level that are integrated into the production accounts at both the top and the bottom of the production system and are fully coherent across industries.

III. Benefits of the Integration

There are several benefits of having a productivity account integrated to the System of national accounts.

1. Consistency

The Input/Output tables (IOT) play a central role in the integration of the CSNA and the CPA contribute to this interactive system. As noted in the accompanying paper, the IOT provides the framework that is used to identify gaps and point to inconsistencies.

The IOT provide a framework for checking the consistency of data on flows of goods and services obtained from a variety of statistical sources—industrial surveys, household expenditures, investment surveys, foreign trade statistics, etc. The IOT serves as a coordinating framework for productivity statistics, both conceptually for ensuring the consistency of the definitions and classifications used and as an accounting framework for ensuring the numerical consistency of data drawn from different sources.

While the productivity accounts not only benefit from this coherent unified framework, they also provide important feed back that helps to identify inconsistencies. The basic production framework worries primarily about balancing commodity supply and disposition, about the relationship between sales and factor incomes. The productivity accounts provide additional checkpoints—asking whether the increase in real outputs is reasonable relative to both labour and capital inputs.

The CPA also provide a set of summary data series that serve to provide a constant check on the time series validity of the SNA. As part of its estimation system, the CPA create a database containing coherent data on prices and volumes along with data on capital and labour inputs–KLEMS. The KLEMS database allows additional perusal of relationships that emerge from the data produced by the IOT—especially during research projects.

These projects allow the productivity program to improve both data accuracy and data suitability by contributing to the production of time series that are consistent over time. But, by their nature, the survey systems that provide data to the National Accounts are often not ‘time-series’ consistent. Amongst other changes, industry classification systems have changed from being SIC-based to being NAICS-based. Surveys (such as the Annual Survey of Manufactures) change their coverage. Each of these changes may improve survey estimates at a given point in time—but serve to render analysis over time less coherent. While rough corrections are often provided by survey programs to account for the impact of changes in coverage or classification, the survey programs rarely provide all of the changes that are required to provide time-series coherence. One of the primary focuses of the productivity program, as it prepares the time series used for the program and as it feeds back information to the production divisions, is to improve the time-series consistency of the data.

The Canadian Productivity Accounts often are used to quantify the sources of Canadian economic growth using a variety of data for individual industries. Industry-level data enable us to trace the sources of Canadian economic growth to their industry origins, to isolate and analyze specific industries, and to assess the relative importance of productivity growth and factor accumulation at both industry and economy-wide levels. Having a set of productivity accounts integrated to the SNA permits the "bottom-up" approach to complement the "top-down" analysis approach cast in the production possibility frontier framework.

One way to ascertain the consistency of the KLEMS data is to inquire whether alternate productivity measures derived at the industry level yield a similar story on the sectoral allocation of aggregate productivity growth. Consider for example the direct contribution to aggregate productivity growth from two distinct groups of industries – those that produce information technology and those that use information technology.

In a recent study, we used both the top down approach and the bottom up approach to study this issue[15]. Regardless of the methodology used, the data show a contribution to aggregate productivity in the 1990s from the two groups, although the majority comes from IT-using industries. Using the notion of gross output, information technology-using industries contributed 0.89 percentage points to the 1.10 percent growth of the Canadian business sector's multifactor productivity growth during the late 1990s. This result remains robust to alternate measures of output (value added and sectoral output), albeit with significant differences in the order of magnitude of the results as one would expect.

2. Quality assessment

Because productivity estimates 'integrate' data on outputs and inputs in current and constant prices that are collected from a variety of different sources, they constitute a convenient way to ascertain the quality of data obtained from the CSNA. This constitutes more than just improving the coherency of existing data, but also suggesting major data gaps.

For example, the perusal of productivity results at the industry level may suggest sectors where deficiencies need to be addressed. For an analyst who is confirming GDP estimates, finding a positive output growth of an industry that does not show any sign of decline may be sufficient. But when productivity estimates have been integrated into the production system, that same analyst can compare the trend of output to the trend of inputs based on consistent data and ask whether the long term trends in productivity are reasonable.

[15] See Harchaoui and Tarkhani (2004a) and Harchaoui at al. (2004).

For example, Gullickson and Harper (1999) suggest that a negative—or even a sluggish—productivity growth over a long period of time for an industry that is not declining is indicative of problems in the quality of the output and/or input estimates.

There are a number of Canadian sectors that display sluggish multifactor productivity performance (an average annual growth rate less than 1 percent) for the period 1981-2000 and the 1981-88 and 1988-00 sub-periods. These include a number of service sector industries--accommodation and food, business service, personal and household service, amusement and recreational service. As a result, Statistics Canada has mounted an initiative to improve price measurement in these areas.

Elsewhere, in finance, real estate and insurance, growth rates are also relatively low. Here the problem probably has more to do with the problem associated with the development of markets for leased capital. The Canadian system attributes investment to the sector of capital ownership not of capital use. The lower productivity growth rates here conceivably could be the result of very high capital input due to this leasing phenomenon.

3. Flexibility

The integration between the productivity accounts and the SNA gives flexibility to the CPA in that it allows for the production of a variety of productivity measures that are needed to provide measures for specific purposes that are consistent with those produced by the core program.

Alternate Productivity Measures

Neither the economics profession nor international statistical agencies have settled on a single productivity measure for all purposes. Producing a variety of productivity measures allows Statistics Canada to meet diverse requests for alternate summary statistics for specific purposes—in particular, for cross-country comparisons.

Many national productivity programs like those of Australia and the U.K. exclusively produce value-added productivity measures at different levels of aggregation. In contrast, depending on the level of aggregation, the BLS uses different notions of output. The source of the real output measures for the BLS business and nonfarm business productivity measures is the national income and product accounts (national accounts), produced by the Bureau of Economic Analysis of the U.S. Department of Commerce.

The BLS also used the notion of value added (or gross output originating) for its manufacturing productivity measures until 1996 and, has subsequently, used a "sectoral output" concept to measure manufacturing output.

The notion of gross output has been extensively used by Dale Jorgenson and his associated in a variety of research projects on productivity (see Jorgenson and Stiroh 2000 for example).

The integration of the Canadian productivity accounts to the SNA allows Statistics Canada to produce productivity estimates based on value added, sectoral output, and gross output. In doing so, it has established a program allowing comparisons between Canada and the U.S.. In recent years, several research projects that seek to expand the international scope of the CPA have been initiated.[16]

Producing alternate productivity measures satisfies a range of analytical needs that otherwise cannot be met by a single measure of productivity. Recent requests have been received to consider the role of intermediate inputs and changing levels of intermediation on productivity performance. Increases in imports, the use of business services, such as equipment leasing, computer services, and the use of temporary labour—all of which can have an important impact on production and employment—may have affected productivity. The role of intermediate inputs is invisible when value added is used, which is a "net output" measure. On the other hand, the use of gross output measures that consider the role of materials directly allows for analysts to study of what is happening with intermediate materials and services. Flexibility due to the integrated nature of the CSNA permits the development of alternate productivity measures to meet different analytical needs.

Testing Assumptions

Despite the professionalism and energy that is devoted to the Canadian System of National Accounts, there are areas where improvements can be made. And occasionally, queries will be made as to whether these improvements would change the nature of the story that productivity numbers are telling.

Having an integrated system allows the CPA to produce productivity estimates with slight changes in the underlying system in order to test the robustness of the productivity estimates. For example, the CPA recently tested the effect of alternate price deflators for information technology products on Canada/U.S productivity estimates.

Differences in the measurement of information technology prices have recently attracted professional interest. The construction of a consistent time series of constant price series on information technology requires the availability of 'constant-quality price indexes.' These prices capture quality improvements across successive generations of information technology products and treat these quality gains as a reduction in the price of information technology.

The use of different techniques to measure quality changes by different countries has been cited as a reason for noncomparability of international comparisons. For example,

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[16] See Harchaoui et al. (2003) for a Canada-Australia comparison in terms of standards of living and productivity, Harchaoui et al. (2004) and Ho et al. (2004) for a Canada-U.S. comparison based on the notion of gross output utilised by Dale Jorgenson, and Harchaoui and Tarkhani (2004a) for a Canada-U.S. comparison based on official productivity measures produced by Statistics Canada and BLS.

Wyckoff (1995) examines computer price methodologies for several countries and finds that both the matched model and the hedonic techniques are employed. He argues that the difference in price behavior can be significant, depending upon the technique chosen. Further, based on the results of studies of U.S. data, he notes that typically the matched model index falls at a slower rate than the hedonic index.

The U.S. statistical system has been at the forefront of the development of quality adjusted price indexes for information technology goods over the last twenty years. Over the same period, Canada has made sustained efforts to monitor these developments and to implement them in its statistical system. Quality changes are reflected to varying degrees in commodities and assets of final demand categories of information technology that appear in Canada's Income and Expenditures Accounts and in the Input/Output Accounts.

Although there are some major differences in terms structures of the two economies and data sources that might lead to differences in price indices, it is still useful to benchmark the behaviour of Canadian information technology prices to those of the U.S. at both the aggregate and industry levels to ascertain whether Canadian prices differ much from their U.S. counterparts.

There are important similarities between Canada and the U.S. in some categories of final demand. The implicit price index of Canadian imports to Canada of information technology tracks the U.S. information technology export price index fairly closely over the 1981-2000 period. On the investment side, important similarities in the price behaviour also exist for computers. Similarities also exist between Canadian and the U.S. implicit prices of personal expenditures' goods and services. In contrast, Canada's prices for telecommunication equipment on the investment side are different.
Differences in the behaviour of information technology prices also exist at the industry level and their impact on the productivity performance of these industries can be quite significant. Two recent papers have compared between the role of information technology in economic growth in Canada and the United States, while asking how much different deflators affect the results. These papers used an 'internationally harmonized' deflator for output and intermediate inputs, based on the implicit prices (adjusted for the exchange rate) from the United States KLEMS database. The harmonized deflator drops much faster than the prices in the Canadian productivity accounts.
Even with the harmonized price indexes, there is still a multifactor productivity growth gap in favour of U.S. information technology-producing industries. Moreover, overall conclusions about the sources of the productivity revival in Canada in the late 1990s and comparisons of overall differences to the US are not affected by the replacement of Canadian with U.S. prices. The use of a harmonized price index does not alter the result that Canada's productivity revival is to a large extent attributable to information technology-using industries (see Harchaoui and Tarkhani 2004a and Harchaoui et al. 2004).

Extending Coverage

The CPA construct productivity measures that cover the business sector, which is defined as the total economy less general government (including publicly provided health and education) and owner-occupied dwellings. But for some analytical purposes, there is need for a different sectoral coverage. The availability of a set of productivity accounts allows relatively minor variations to be readily constructed in aid of special projects.

One such example comes from a recent project done in conjunction with Industry Canada and Dale Jorgenson of Harvard, which required a productivity measure that treated owner-occupied dwellings and consumer durables as investments rather than as consumption as is done in the traditional estimates.

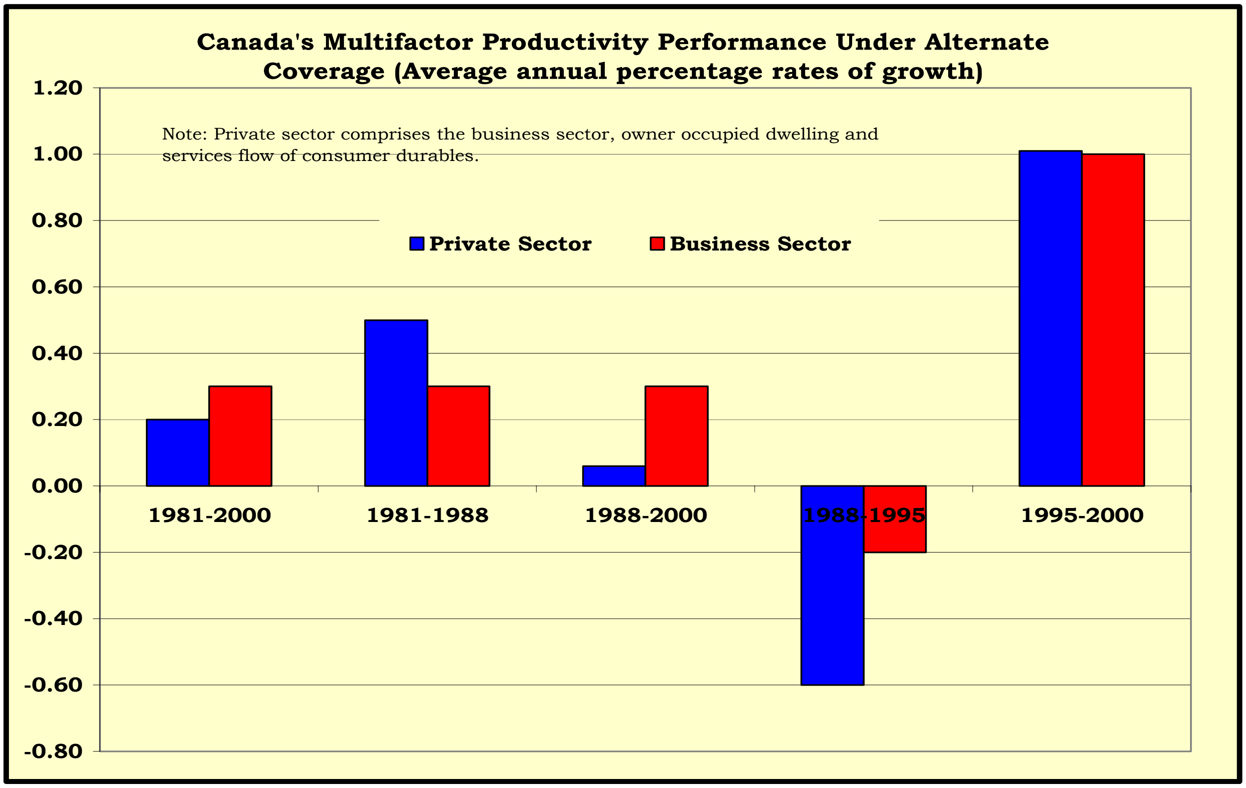
For this exercise, expenditures on owner-occupied dwellings were treated as investments in assets that provide a flow of services over many periods. The purchase of new housing was considered as an investment, while the flow of services from the installed stock was allocated to consumption and housing capital services were considered as part of capital input.

For the sake of consistency, consumers' durable goods were also treated symmetrically with housing capital since both are essentially long-lived assets that generate a flow of services over the life span of the asset. Capitalizing consumer durables reallocates expenditures that are made on them from personal consumption expenditures to gross private domestic investment and increases GDP by the amount of services they provide.

To implement these changes, we adopted a methodology similar to that used for the calculation of capital services. We used a rental price to impute a flow of services from consumers' durables to be included in consumption and add a measure of capital invested in consumer durables to capital input. The rate of return on the service flow of housing was imputed from rental values available from the Income and Expenditures Accounts and the capital stock.[17] Capital services were then estimated using the same methodology used for other assets.

Figure 1 shows the impact of these changes on multifactor productivity growth. With broader concepts of output and input, the output and income share attributed to the fastest growing components falls, with the result that Canadian multifactor productivity shows a slightly slower growth.

[17] See Harchaoui and Tarkhani (2004b) for a description of the methodology.



IV. The Challenges Ahead

Statistics Canada has made sustained efforts to improve its productivity measures. These efforts have been devoted to enhancing the reliability of the measures; improving the quality of product, and improving the range of information provided to the public. Despite the progress that has been made by the program, there is room for improvement.

Efforts are underway to expand the CPA coverage to consider unpriced goods and assets such as environment and public capital. These efforts depend once more on the existence of data sources that can be merged with the economic accounts.

1. Unpriced Goods and Assets

While the environment is affected by economic activity, most measurement is done of the two separately, that is, measures of the environment tend to be collected by environmental agencies while measures of economic activity tend to be collected by national accountants.

The Canadian System of National Accounts contains an environmental group whose task has been to collect data and integrate it into the larger framework of supply and use that provides the foundation for the Accounts. Because of their work, the productivity accounts has been able to ask how productivity measures can be expanded to take into account how the industrial system makes use of the environment.

Ideally, estimates of productivity growth should take account of all inputs and outputs associated with a production process, including changes to the environment. In practice, productivity growth is normally estimated using techniques that only take account of inputs and outputs that are priced. There are two reasons for this. First, data on environmental conditions are rarely collected that can be merged with data on economic activity. Second, since most environmental impacts are not traded in markets, they rarely have observable prices, and are not measured by the traditional economic accounting system, and so tend to be ignored when estimating productivity growth.

The impact of the environment on the productive performance of firms is an important issue facing society. However, detailed evaluation is difficult to obtain since the price paid for the use of the environment is either zero or well below its opportunity cost. Because the consumption of the environment involves true opportunity costs no less than does the consumption of labour, capital or material inputs, the standard multifactor productivity growth measure may be viewed as an incomplete barometer of efficiency improvements in the economy.
The purpose of extensions of the productivity program under this broad theme is to develop productivity measures that incorporate unpriced environmental impacts and apply them in an experimental way to two of the environmental issues facing Canada—greenhouse gas emissions and water use.

The methodology that has been adopted uses a cost-function-based model of production processes in the Canadian business sector to represent producers' input and output decisions and to estimate productivity in the face of unpriced factor inputs and outputs. (see Harchaoui and Lasserre 2003). Earlier work in this area includes the paper by Gollop and Swinand (1998). Emissions are joint outputs of the industrial process and can be included in the output index with weights determined by their marginal costs. And the latter can be estimated with the help of the type of industry cost functions that can be generated using the CPA's KLEMS database.

The methodology takes into account a potential source of productivity growth that the conventional methodology misses: a more rapid growth in the value of total output due to a shift toward highly valued marketable products and away from negatively valued waste products. This is as valid and potentially important an efficiency gain as any other. In some Canadian industries, it has been an important source of improvement in productivity performance.

The experimental estimates show that when the standard productivity framework is adapted to take into account undesirable by-products, the conventional measure of productivity growth increases in value—by about 15%. This occurs because the economy has been increasing the amount of GDP that is produced faster than the amount of CO2 emissions that is produced.

2. Natural Resources and Capital Stock

Most productivity estimates take into account only produced machinery and equipment, or buildings, or engineering construction. While this is adequate for the majority of sectors, it is not for the mining sector as natural capital (mineral reserves stocks) is important here and it is generally not correctly incorporated by the conventional productivity framework.

The CPA have therefore been engaged in efforts to modify the framework that it uses to estimate multifactor productivity in the extractive sector. Once more these efforts depend upon the integration of the environmental accounts and the productivity accounts. The environmental group within the CSNA has also produced estimates of the stock of natural resources—various minerals, petroleum, gas and timber. Both quantities and values of these stocks are maintained. Using these, more direct values of the actual resources that are used in production and the depletion thereof can be directly considered in the productivity analysis.

Those efforts have led us to separate the activities of the mining sector into extractive as opposed to exploration and to specify the corresponding production framework by introducing natural capital for the extractive sector. This has led to a reassignment of a portion of produced capital that was initially assigned to extractive industries to exploration and development activity. The result has been a threefold increase of multifactor productivity for the extraction activity of the mining sector from over the 1981-2000 period.[18]

3. Public Capital and Productivity

Public infrastructure assets, defined in terms of dams, roads, highways, railways, ports, bridges, airports, streets, water and sewer systems, have long been part of the balance sheet accounts and gross domestic product.

They are not part of the official productivity estimates. This is primarily because it is more difficult to estimate their flow of services than it is for private capital. In particular, it is probably not appropriate to use the convention used in the national accounts that treats the net operating surplus of public capital as consisting only of depreciation. At present, the net return to fixed assets used by general government and nonprofit institutions serving households for non-market production is assumed to be zero (SNA 6.91).

Use of depreciation as a measure of the value of services of government fixed assets is a partial measure. In theory, the service value of an asset should equal the reduction in the value of the asset due to its use during the current period (depreciation) plus a return equal to the current value the asset could earn if invested elsewhere (net return).

[18] See Harchaoui and Tarkhani (2003c).

There are alternate ways for estimating the rate of return to general government fixed capital formation and one of them consists of using econometric models. Many of these regress output on labour, private capital, general government capital, and a constant for the level of technology. The estimated coefficient for government capital can be used to derive an estimate of the marginal product of government capital.

The CPA have been developing new productivity estimates that take into account the role that public capital plays in the private sector and incidentally produces a rate of return for public capital. A recent Statistics Canada study (see Harchaoui and Tarkhani 2003d) has employed a dual cost function and estimated the private cost saving arising from public capital services.

V. Concluding Remarks

Statistics Canada measures the quality of its product using five criteria—timeliness, accuracy, coherence, relevance and interpretability. The integrated set of productivity accounts makes contribution to each of these objectives. As indicated previously, the feedback from the productivity group to the production accounts directly contributes to improvements with respect to accuracy. By integrating labour and capital services into the production accounts, the CPA improve the coherence of the overall product. By developing the KLEMS database, it aids in improving time series consistency and overall coherence. By expanding the type of products that are produced into the area of the environment, it has contributed to improvements in relevance. By developing a set of compatible products that can be used in cross-country comparisons, it contributes to the goal of interpretability—by providing data that allow appropriate use for cross-country comparisons. By building on the integrated system of accounts, it provides both timely quarterly data and more detailed industry detail, with a lag, that are fully compatible.

All of this is and could only have been done within the framework of an integrated set of national accounts. The productivity accounts are an integral part of that framework. This has not always been the case. Fifteen years ago, productivity was calculated by a group that was only imperfectly integrated into the main production accounts. Reorganizations have reduced the gap between the two. Closer integration has developed partially as a result of a general improvement in the degree of consistency across the various national accounts programs. Cost pressures have caused the production process to seek ways to improve the general editing process and seek inputs from sources not previously consulted. In addition, the productivity program recognized that it was increasingly important to be using estimates of output and inputs that were replicable by outsiders from published series of outputs. In the end, the productivity group at Statistics Canada has become an integral part of the Accounts—similar to the Input/Output, the Income and Expenditure, the Industry Measures and the Balance of Payments groups.

Appendix A: What do the UK, France and Australia do in terms of productivity measurement?

1. Current status

All these countries have a limited productivity program that relies on the notion of value added at the aggregate level and some major sub-sectors.

1. For example, the ONS publishes quarterly labour productivity estimates based on value added for the whole economy, the production sector, total manufacturing and 11 manufacturing subsectors.

   Recently, the ONS has introduced annual labour productivity estimates at a more detailed industry level based on a new survey vehicle (Annual Business Inquiry). This data source has the advantage of bringing together accounting and employment data and improving the consistency between output and labour measures making the compilation of detailed labour productivity measures feasible. It however recognized that the gross value added measures compiled from the ABI are approximate as the full range of variables necessary to calculate the true value added is not available and the estimates differ from Input-Output final numbers (Daffin and Lau 2002).

   The ONS does not have a multifactor productivity program. Recently, however, the ONS has given priority to the development of experimental multifactor productivity estimates (Lau and Vaze 2002) for two reasons:

   a. Most countries have experienced a multifactor productivity revival, but independent estimates developed at the Bank of England and at the National Institute of Economic and Social Research have shown that U.K. relative multifactor productivity performance deteriorated relative to the U.S. in the post-1995 period compared to the early 1990s. Public pressure has led the ONS to find out whether this is a real phenomenon or a result of a data problem (adequate deflators in particular);
   b. ONS recognizes the usefulness of multifactor productivity estimates as a valuable quality assurance tool to check consistency of output and input data.

2. Australia has also a regular productivity program that produces annual labour productivity and multifactor productivity measures based on real value added.

   Aggregate multifactor and labour series for the market sector are maintained from the early 1960s to the most recent years. These multifactor productivity series are based on hours at work and capital services. Recently, the ABS has introduced multifactor productivity series for the period 1982 onward with labour input estimates that account for compositional changes. Subsector productivity series are only available for labour productivity measures and they are maintained from 1992 to the most recent years.

3. Unlike the other two countries, France does not maintain an ongoing productivity program. While the majority of statistical offices view productivity measures as an ongoing statistical program, INSEE views them more as an input for analytical papers with little connection to the system of national accounts. INSEE does not produce 'official' productivity series, but its various directorates release regular analytical studies based on real value added series.

There is a common denominator for all productivity programs of these countries. Value added is the primary vehicle used to measure output. This is primarily due to a) the absence of input-output tables in constant prices and b) a focus primarily on productivity only for aggregate sectors.

2. Data sources

The lack of a comprehensive set of input-output tables in constant prices has led all these countries to maintain a limited productivity program with a unique measure of output and a limited set of subsectors.

All these countries have a long history of compiling input-output tables in current prices but it is only recently that significant efforts were made to develop input-output tables in constant prices. For example, Input-Output balances at current prices are now a central part of the United Kingdom's National Accounts. Since 1992 the input-output framework has been fully integrated within the National Accounts' production process. Annual current price input-output supply-use tables are now the mechanism used to ensure consistency between the production, income and expenditure components of GDP. The result has been estimates of GDP, at current prices, that not only have greater internal coherence but also a higher quality.

Constant Price Input-Output Supply and Use tables are increasingly receiving international recognition as the best way in which to balance the constant price national accounts and produce constant price GDP. A number of countries, including the Netherlands, Canada and Denmark, already balance their accounts in this way.

For example Australia decided to adopt an 'input-output' approach to compiling the annual national accounts. The decision to adopt this methodology was driven by a number of factors including the desire to produce balanced measures of GDP and to provide improved measures of value added by industry in volume terms through double deflation. The first set of I-O tables compiled on this basis were the 1994 tables, which were released in March 1999. A second set of tables on this basis were compiled in respect of 1996 and these were released in March 2001.

Since late 1996 the ONS has been investigating the feasibility of producing constant price input-output supply and use tables for the UK. That initiative was supposed to be completed in 2002 (Powell 2002).

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