What Is To Be Done for Better Productivity Measurement

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ABSTRACT

The first section of the article reviews general measurement problems associated with measuring sectoral total factor productivity. Secondly, the article argues that the production accounts in the present System of National Accounts (SNA) need to be extended somewhat in order to be suitable as a data base for measuring sectoral productivity growth rates. In particular, the treatment of exports, imports and indirect taxes is not completely adequate for productivity measurement purposes in the present SNA. Finally, the article makes some specific suggestions to statistical agencies that would lead to better productivity measurement. In particular, balance sheet information needs to be improved and made available to the public. Moreover, the balance sheet information needs to be integrated with sectoral measures of capital service inputs.

PRODUCTIVITY HAS LONG BEEN recognized as the key source of improvements in living standards. To understand productivity trends and to develop policies to improve productivity performance, it is crucial to measure productivity accurately. This task represents a major challenge to economists, both because of conceptual issues and data constraints. The objective of this article is to provide an overview of measurement problems that arise in the estimation of productivity growth at the establishment, firm, industry and economy level and to suggest ways to address these problems.

The first section of the article provides an overview of general problems associated with the measurement of total factor productivity (TFP), showing that the KLEMS (capital, labour, energy, materials and services) framework is not the end of the story but it is a good beginning. The second section considers some of the problems with the production accounts in the *System of National Accounts 1993* (*SNA 1993*) that make one cautious about the validity of industry TFP growth estimates that use national statistical agency real input-output tables as inputs into their productivity estimates. The third section considers some of the data problems that the author encountered while attempting to construct estimates of TFP growth for the Canadian business sector over the 1961-2006 period. The fourth and final section offers a brief conclusion.

General Problems for the Measurement of Total Factor Productivity

In this section,[2] we examine certain general problems that arise when we attempt to measure the total factor productivity of an enterprise, industry or economy. The methodology for measuring the TFP of a production unit was

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2 This section draws on Diewert (2001).

developed by Jorgenson and Griliches (1967 and 1972) and will not be repeated here. Basically, TFP growth between two time periods for a production unit is equal to a quantity index of output growth (or net output growth) divided by a quantity index of input growth.[3]

Gross Outputs

In order to measure the productivity of a firm, industry or economy, we need information on the outputs produced by the production unit for each time period in the sample along with the average price received by the production unit in each period for each of the outputs. In practice, period by period information on revenues received by the industry for a list of output categories is required along with either an output index or a price index for each output. In principle, the revenues received should not include any commodity taxes imposed on the industry's outputs, since producers in the industry do not receive these tax revenues. The above sentences sound very straightforward but many firms produce thousands of commodities so the aggregation difficulties are formidable. Moreover, many outputs in service sector industries are difficult to measure conceptually: think of the proliferation of telephone service plans and the difficulties involved in measuring output in insurance, gambling, banking, and options trading.

Intermediate Inputs

Again, in principle, we require information on all the intermediate inputs utilised by the production unit for each time period in the sample along with the average price paid for each of the inputs. In practice, period by period information on costs paid by the industry for a list of intermediate input categories is required along with either an intermediate input quantity index or a price index for each category. In principle, the intermediate input costs paid should include any commodity taxes imposed on the intermediate inputs, since these tax costs are actually paid by producers in the industry. On the other hand, taxes that fall on the outputs produced by the production unit should be excluded for productivity measurement purposes.[4]

The major classes of intermediate inputs at the industry level are:

- materials
- energy
- business services
- leased capital.

The current input–output framework deals reasonably well in theory with the flows of materials but not with intersectoral flows of contracted labour services or rented capital equipment. The input-output system was designed long ago when the leasing of capital was not common and when firms had their own in-house business services providers. Thus there is little provision for business services and leased capital intermediate inputs in the present system of accounts. With the exception of the manufacturing sector, even the intersectoral value flows of materials are often incomplete in the industry statistics (due to the lack of surveys).

This lack of information means the current input-output accounts will have to be greatly expanded to construct reliable estimates of real value added by industry. At present, there are no surveys (to our knowledge) on the interindustry flows of business services or for the interindustry flows of leased capital. Another problem is that using present national accounts conventions, leased capital resides in the sector of ownership, which is generally the finance sector.

3 Diewert and Morrison (1986) and Kohli (1990) provide an exact index number justification for this methodology based on flexible functional form production theory. Note that no separability assumptions about outputs and inputs are required using this methodology.

4 These conventions for the treatment of indirect taxes on outputs and intermediate inputs when measuring productivity date back to Jorgenson and Griliches (1972; 85).

This could lead to a large overstatement of the capital input into finance and a corresponding underestimate of capital services into the sectors actually using the leased capital unless some care is taken in reconciling the primary and intermediate input accounts for owned and leased capital services.

It should be noted that at the level of the entire market economy, intermediate inputs collapse down to just imports plus purchases of government and other nonmarket inputs. This simplification of the hugely complex web of interindustry transactions of goods and services explains why it may be easier to measure productivity at the total economy level than at the industry level. We will pursue this point in more detail in section two.

Labour Inputs

Using the number of persons employed as a measure of labour input into an industry will not usually be a very accurate measure of labour input due to the long-term decline in average hours worked per full-time worker and the increase in the share of part-time workers. However, even total hours worked in an industry is not a satisfactory measure of labour input because industries employ a mix of skilled and unskilled workers. Hours of work contributed by highly skilled workers contribute more to production than hours contributed by very unskilled workers. Hence, it is best to decompose aggregate labour compensation into its aggregate price and quantity components using index number theory. The practical problem faced by statistical agencies is: how should the various categories of labour be defined?[5]

Another important problem associated with measuring real labour input is finding an appropriate allocation of the operating surplus of proprietors and the self employed into labour and capital components. There are two broad approaches to this problem:

- If demographic information on the self-employed is available along with hours worked, then an imputed wage can be assigned to those hours worked based on the average wage earned by employees of similar skills and training. Then an imputed wage bill can be constructed and subtracted from the operating surplus of the self employed. The remaining operating surplus can then be assigned to capital.
- If information on the capital stocks used by the self-employed is available, then these capital stocks can be assigned user costs and then an aggregate imputed rental can be subtracted from operating surplus. The reduced amount of operating surplus can then be assigned to labour. These imputed labour earnings can then be divided by hours worked by proprietors to obtain an imputed wage rate.

The problems posed by allocating the operating surplus of the self employed are becoming increasingly important as this type of employment grows in many countries. Fundamentally, the current SNA does not address this issue adequately.

Reproducible Capital Inputs

When a firm purchases a durable capital input, it is not appropriate to allocate the entire purchase price as a cost to the initial period when the asset was purchased. It is necessary to distribute this initial purchase cost across the useful life of the asset. National income accountants recognize this and use depreciation accounts to distribute the initial cost over the life of the asset. However, national income

5 Alternative approaches to this problem are outlined in Jorgenson and Griliches (1967), the Bureau of Labor Statistics (1983), Jorgenson, Gollop and Fraumeni (1987) and Jorgenson and Fraumeni (1989 and 1992). Dean and Harper (2001) provide an accessible summary of the literature in this area.

accountants are reluctant to recognize the interest tied up in the purchase of the asset as a true economic cost. Rather, they tend to regard interest as a transfer payment. Thus the user cost of an asset (which recognizes the opportunity cost of capital as a valid economic cost) was not regarded as a valid approach to valuing the services provided by a durable capital input by many national income accountants, and in SNA 1993 in particular.

However, if a firm buys a durable capital input and leases or rents it to another sector, national income accountants regard the induced rental as a legitimate cost for the using industry. It seems very likely that the leasing price includes an allowance for the capital tied up by the initial purchase of the asset, i.e. market rental prices include interest. Hence, it seems reasonable to include an imputed interest cost in the user cost of capital even when the asset is not leased. Put another way, interest is still not accepted as a cost of production in the SNA, since it is regarded as an unproductive transfer payment. But interest is productive; it is the cost of inducing savers to forego immediate consumption. This difficulty with SNA 1993 has been recognized in the current revision process for the internationally approved System of National Accounts and the next version of these accounts will allow for a decomposition of gross operating surplus in the accounts into price and quantity components where the price of capital services will be a user cost concept (Schreyer, 2001 and 2007).

The treatment of capital gains on assets is even more controversial than the national accounts treatment of interest. In the national accounts, capital gains are not accepted as an intertemporal benefit of production but if resources are transferred from a period where they are less valuable to a period where they are *anticipated* to be more highly valued, then to user cost proponents, a gain has occurred, i.e. capital gains are productive according to this view.

However, the treatment of interest and capital gains pose practical problems for statistical agencies. For example, which interest rate should be used?

- An ex post economy wide rate of return which is the method used by Christensen and Jorgenson (1969 and 1970)?
- An ex post firm or sectoral rate of return? This method seems appropriate from the viewpoint of measuring ex post performance.
- An ex ante safe rate of return like a federal government one year bond rate? This method seems appropriate from the viewpoint of constructing ex ante user costs that could be used in econometric models.
- Or should the ex ante safe rate be adjusted for the risk of the firm or industry?

Since the ex ante user cost concept is not observable, a statistical agency will have to make somewhat arbitrary decisions in order to construct expected capital gains. This is a strong disadvantage of the ex ante concept. On the other hand, the use of the ex post concept will lead to rather large fluctuations in user costs, which in some cases will lead to negative user costs. This may be hard to explain to users. However, a negative user cost simply indicates that instead of the asset declining in value over the period of use, it rose in value to a sufficient extent to offset deterioration. Hence, instead of the asset being an input cost to the economy during the period, it becomes an intertemporal output.[6]

A further complication is that our empirical information on depreciation rates for reproducible assets is often weak. In general, we do not

6 For further discussion on the problems involved in constructing user costs, see Diewert (1980: 470-486; 2005a; and 2006) and Schreyer (2001 and 2007). For evidence that the choice of user cost formula matters, see Harper, Berndt and Wood (1989).

have good information on the useful lives of assets. In past years, the UK statistician assumed that machinery and equipment in manufacturing lasted on average 26 years while the Japanese statistician assumed that machinery and equipment in manufacturing lasted on average 11 years (OECD 1993; 13).[7]

A final set of problems associated with the construction of user costs is the treatment of business income taxes: should we assume firms are as clever as Hall and Jorgenson (1967) and can work out their rather complex tax–adjusted user costs of capital or should we go to the accounting literature and allocate capital taxes in the rather unsophisticated ways suggested there?

Inventories

Because interest is not a cost of production in the national accounts and the depreciation rate for inventories is close to zero, many productivity frameworks neglect the user cost of inventories. This leads to misleading productivity statistics for industries where inventories are large relative to output, such as retailing and wholesaling. In particular, rates of return that are computed neglecting inventories will be too high since the opportunity cost of capital that is tied up in holding the beginning of the period stocks of inventories is neglected.

The problems involved in accounting for inventories are complicated by the way accountants and the tax authorities treat inventories. These accounting treatments of inventories are problematic in periods of high or moderate inflation.[8] These inventory accounting problems seem to carry over to the national accounts in that for virtually all OECD countries, there are time periods where the real change in inventories has the opposite sign to the corresponding nominal change in inventories. This is difficult for users to interpret.[9]

Land

The current SNA has no role for land as a factor of production, perhaps because it is thought that the quantity of land in use remains roughly constant across time and hence can be treated as a fixed, unchanging factor in the analysis of production. However, the quantity of land in use by any particular firm or industry does change over time. Moreover, the price of land can change dramatically over time and thus the user cost of land will also change over time and this changing user cost will, in general, affect correctly measured productivity.[10]

Land ties up capital just like inventories (both are zero depreciation assets). Hence, when computing ex post rates of return earned by a production unit, it is important to account for the opportunity cost of capital tied up in land.

7 The Economic and Social Research Institute (ESRI), Cabinet Office of Japan, under the direction of Koji Nomura, has implemented a new survey on retirements and sales of assets which should lead to better estimates of depreciation rates for capital stocks in Japan. Canada, the Netherlands and New Zealand have similar surveys.

8 A treatment of inventories that is suitable for productivity measurement can be found in Diewert and Smith (1994).

9 See Diewert (2005b) for a more coherent framework for measuring inventory change and the user cost of inventories.

10 Diewert and Lawrence (2000:285) in their Canadian TFP study showed that neglecting land and inventories decreased the TFP growth rate by about 20 per cent, i.e. when land and inventories were omitted as factors of production with their own user costs, the Canadian TFP growth rate fell from 0.68 per cent per year over the period 1962-1996 to 0.55 per cent. In a similar study for Japan, Nomura (2004; 347) showed that the Japanese TFP growth rate fell from 1.54 per cent per year over the period 1960-2000 to 0.80 per cent per year when land and inventories were omitted. These studies indicate the importance of including land and inventories as productive factors in productivity studies. Due to lack of data, EUKLEMS does not have land or inventory services as primary inputs in its data base (Timmer, O'Mahony, and van Ark, 2007).

Neglect of this factor can lead to biased rates of return on financial capital employed. Thus, industry rates of return and TFP estimates may not be accurate for sectors like agriculture which are land intensive.

In many countries, the long run trend in the price of land can be higher than the opportunity cost of capital for the sector that is using the land as an input into its production function. This means that even the ex ante user cost of land can be negative which can lead users to question the user cost methodology. The problem of negative user costs can also arise in the context of finding a price for the use of an owner occupied dwelling unit. In this CPI context, Diewert (2007a: 27) suggested the following solution to the negative user cost problem:

> We conclude this section with the following (controversial) observation: perhaps the "correct" opportunity cost of housing for an owner occupier is not his or her internal user cost but the *maximum* of the internal user cost and what the property could rent for on the rental market. After all, the concept of opportunity cost is supposed to represent the *maximum sacrifice* that one makes in order to consume or use some object and so the above point would seem to follow. If this point of view is accepted, then at certain points in the property cycle, user costs would replace market rents as the "correct" pricing concept for owner occupied housing, which would dramatically affect Consumer Price Indexes and the conduct of monetary policy.

The same logic could be applied to the problem of finding prices for the use of commercial and industrial land in productivity accounts: the "correct" *opportunity cost price* is the *maximum* of the financial opportunity cost for using the land during the accounting period (its ex ante user cost) and the market rent for the use of the land during the period. If this point of view were adopted, the problem of negative user costs would vanish.

As a final complication, property taxes that fall on land must be included as part of the user cost of land. However, it may not be easy to separate the land part of property taxes from the structures part.

Resources

The costs of using up nonrenewable natural resources should also be included in a productivity framework as should environmental degradation and pollution costs. However, since the current SNA 1993 makes no provision for these costs and most countries have not developed data on these costs, we will just mention this topic as one that deserves attention in the next revision of the System of National Accounts. When data on natural resource stocks and environmental "bads" are made available in the SNA, then we will be able to measure TFP growth in a more satisfactory manner.

Other Stocks and the Capitalization of R&D Problem

There are also additional types of capital that should be distinguished in a more complete classification of commodity flows and stocks, such as knowledge or intellectual capital, patents, trademarks, working capital or financial capital, infrastructure capital and entertainment or artistic capital.[11] Knowledge capital, in particular, is important for understanding precisely how process and product innovations (which drive TFP growth) are generated and diffused. Basically, knowledge capital is society's set of recipes or blueprints for production functions.

R&D expenditures generally add to society's stock of knowledge. The immediate importance of R&D expenditures is that the current revision

11 See Corrado, Haltiwanger and Sichel (2005) for papers on these topics.

process for the international System of National Accounts will recommend capitalizing R&D expenditures. There are many unresolved issues surrounding exactly how to measure the benefits of R&D expenditures and exactly how to depreciate the costs of R&D investments over time.[12] A major problem is that there is a tendency in the R&D literature to treat R&D stocks as just another form of reproducible capital which depreciates just like structures or machines. However, R&D depreciation is not at all like wear and tear depreciation: knowledge capital depreciates due to obsolescence (new and better goods and processes replace existing new goods and new processes) or to shifts in household tastes. Moreover, the *competitive model of producer behavior* serves as the backbone of the existing SNA production accounts but the development of new goods and processes is all about obtaining a competitive advantage and producers must recover their R&D expenditures by setting prices above the marginal costs of production; that is innovation almost always involves non-competitive pricing and monopolistic markups. Thus the capitalization of R&D expenditures in the revised SNA is far from straightforward and doing this job properly will lead to major changes throughout the national accounts. The present Jorgenson and Griliches (1967 and 1972) growth accounting methodology will also have to be extensively revised in order to account for knowledge expenditures in a realistic manner.

The Treatment of Exports, Imports and Indirect Taxes in the SNA

The measurement problems that were discussed in the previous section are general problems that arise when we attempt to measure the productivity of any establishment, industry or economy. However, there are additional measurement problems that arise when the gross output and intermediate input accounts in the *System of National Accounts 1993* are used to measure the productivity growth of industrial sectors. In particular, in this age of globalization, we would like to see how exports and imports contribute to the productivity growth of particular industries in the economy. The production accounts in *SNA 1993* does not allow us to do this.

The main problem areas with the production accounts in SNA 1993 are as follows:

- The main supply and use tables in the production accounts do not show exports produced by industry and imports used by industry;[13]
- The supply and use tables concentrate on the allocation of *values* of outputs produced and *values* of inputs used but do not give any guidance on how to construct *real* supply and use tables; and
- The role of indirect taxes on outputs and intermediate inputs is not completely spelled out nor is the reconciliation of estimates of real GDP at final demand prices built up from final demand components versus estimates of real GDP built up using information on industry outputs and intermediate inputs.

We briefly discuss each problem in turn.

The first problem is easy to remedy, at least conceptually. All that is needed is a refinement of the commodity classification that is used in the present supply and use tables: a gross output that is being produced by a particular industry in a particular commodity category would be further distinguished as being supplied to the domestic market or as an export while an intermediate input that is being used by a particular industry in a particular commodity category would be further distinguished as being pur-

12 See Diewert (2005a: 533-537) for a discussion of these accounting problems.

13 See Table 15.1 in Eurostat, IMF, OECD, UN and the World Bank (1993)

chased from a domestic supplier or from a foreign supplier and hence in the latter case, would be classified as an import into the sector. Making the above changes to the main production accounts in SNA 1993 would not be a dramatic methodological leap since the present SNA already suggests the above treatment of intermediate inputs as a supplementary table.[14] However, implementing the above extension of the commodity classification in the main production accounts would entail a considerable increase in the costs of producing the national accounts.[15] However, if we want to trace through the implications of globalization and outsourcing for particular industries (and in particular, their effects on productivity by industry), the above suggestion would seem to be the only way forward.[16]

The second problem is methodologically much more difficult. Since the SNA 1993 does not give much advice on how to construct real supply and use matrices, countries that produce constant price input-output matrices tend to use the following methodology that has evolved over the years:

- Construct gross output price indexes using a PPI methodology for the 200 to 1,000 commodities that are distinguished by the statistical agency in its supply and use tables;
- Use these output based PPI indexes to deflate the cells in the corresponding commodity row along all of the industry columns of the matrix of gross output values produced during the accounting period in order to obtain a matrix of real gross outputs by commodity and industry (which is a real make, or supply, matrix); and
- Again use the output based PPI indexes to deflate the cells in the corresponding commodity row along all of the industry columns of the matrix of intermediate input values purchased during the accounting period in order to obtain a matrix of real intermediate inputs by commodity and industry (which is a real use matrix).

The statistical agency then may find that total real supply by commodity does not equal the corresponding total real demand by commodity and various balancing exercises are needed to achieve balance between supply and demand.

Unfortunately, the above procedures used to construct real supply and use matrices are not conceptually sound. The main problem is this: not all of the transactions in a single homogeneous commodity take place at the same price. A seller of a commodity will often change the selling price during the reference period and since purchases of the commodity will be somewhat sporadic over the period, different purchasers will face different average prices for the same time period. This problem could be handled in one of two ways:

- Across the commodity row of the make and use matrices, we could have industry specific prices or
- We could expand the make and use tables so that we distinguish the delivery of goods and services by the purchaser and the seller.

In the second method, the average price for the buyer and seller, arranged in bilateral pairs, would always be the same but of course, the dimensionality of the supply and use tables would be expanded enormously.[17]

14 See Table 15.5 in Eurostat, IMF, OECD, UN and the World Bank (1993)

15 In particular, the country's Producer Price Index program would require extra funding along with increased expenditures on import and export surveys. The proposed IMF *Export Import Price Index Manual* will be methodologically consistent with the existing PPI Manual; see the IMF, Eurostat, ILO, OECD, World Bank and the UN (2004) for the PPI methodology.

16 For a more detailed discussion of how exports and imports could be introduced into the production accounts, see Diewert (2007b and 2007c).

The above problem is not the only one with existing statistical agency methods for constructing real use and make matrices. Another important problem is *aggregation bias*. The commodity classification used in real use and supply matrices is not "pure"; each commodity category will consist of hundreds if not thousands of specific products or items. Since producers will generally not make each of the products in each of the commodity classes and purchasers will not purchase each item in fixed proportions, the assumption that a *single* price index can be used to deflate *every* entry along a commodity row in a supply or use matrix is very dubious indeed.

The tentative conclusion that we can draw from the above considerations is that real use and supply matrices as presently constructed will generally have substantial aggregation errors imbedded in them. Hence industry productivity estimates must be viewed with some caution. Economy-wide expenditure-based productivity estimates are likely to be much more accurate because statistical agencies have generally devoted considerable amounts of resources in order to obtain good deflators for the components of final demand. The problem of finding PPI deflators has not had a high priority until recently when more accurate productivity estimates by industry have been requested by users.

The third problem with the SNA production accounts that we mentioned at the beginning of this section had to do with the role of indirect taxes on outputs and intermediate inputs and the reconciliation of estimates of real final demand GDP with estimates of real GDP built up from the production accounts. We will not explain these problems in detail except to say that they can be solved with the addition of more information on indirect taxes by commodity and industry in some expanded supply and use tables.[18]

What Can Statistical Agencies Do to Improve the Data?

Many of the problems associated with the measurement of productivity can be traced back to the fact that SNA 1993 did not provide adequate methodological advice to national statistical agencies on how exactly to measure capital services. This deficiency is being remedied since the next international version of the System of National Accounts will recognize capital services in the production accounts.[19] This will be a major step forward since it will allow inputs in the SNA production accounts to be decomposed into price and quantity components. The revised SNA will facilitate the development of productivity accounts for each country that implements it. However, only introducing capital services into the SNA will not be sufficient in order to develop accurate sectoral productivity accounts. The revised SNA also needs to consider the following problems:

- More attention needs to be given to the development of basic prices by industry and by commodity, i.e. we need accurate information on the exact location of indirect taxes (and commodity subsidies) by commodity and industry on both outputs and intermediate inputs.
- In order to deal adequately with the complications introduced by international trade, the existing Input-Output production

17 This second method of arranging the make and use matrices was followed in Chapter 19 of the PPI Manual (see the IMF (2004)) and in Diewert (2005c; 2007b; and 2007c). This second method seems to be the most conceptually sound but of course, it would be impossible for statistical agencies to implement it in practice. However, it could be partially implemented and the method serves as a useful benchmark for evaluating possible biases in existing methods.

18 See Diewert (2005c) for a treatment of these problems in a closed economy context and Diewert (2007b) (2007c) for an open economy treatment.

19 See Schreyer (2007) for a preliminary version of a manual on capital measurement which will act as a supplement to the next international version of the System of National Accounts to be released in 2008.

accounts need to be reworked so that the role of traded goods and services can be tracked by industry.

- The treatment of inventory change in the present SNA seems inadequate for the needs of productivity accounts. Inventory change should be integrated with the balance sheet accounts and the user cost accounts.
- The investment accounts need to be integrated with the corresponding balance sheet accounts, both in nominal and real terms.
- The treatment of land in the balance sheets requires additional work, i.e. there are problems in obtaining information on the quantity of land used by each industry and sector and valuing the land appropriately.[20]
- Difficult decisions must be made on the exact form of the user cost formula to be used when measuring capital services, i.e. the revised SNA should make specific recommendations on how user costs should be constructed so that some measure of international comparability can be achieved in the accounts.
- The problems involved in making imputations for the labour input of the self employed (and unpaid family workers) should also be addressed.

The introduction of capital services into the SNA will provide challenges for statistical agencies. However, as national statistical agencies make productivity accounts a part of their regular production of the national accounts, there will be benefits to the statistical system as a whole since a natural output of the new system of accounts will be balancing real rates of return by sector or industry. These balancing real rates of return will provide a check on the accuracy of the sectoral data: if the rates are erratic or very large or very small, this can indicate measurement error in the sectoral data and hence will give the statistical agency an early indication of problems with the data.

This author has recently attempted to look at the productivity performance of the Canadian business sector using available Statistics Canada data. Many data problems were encountered (Diewert, 2008). The main problem is that although Statistics Canada has developed an extensive data base on the use of 30 types of capital by industry back to 1961, it does not make this disaggregated information available to the public.[21] The Statistics Canada KLEMS productivity program has also developed a companion data base on the price and quantity for 56 types of labour used by industry but only highly aggregated information on three types of labour is made available to the public. Without accurate information on the flow of labour and capital services by industry, governments and businesses will not be able to plan ahead for Canada's future. It is important to know past trends in TFP growth by industry so that future trends can be anticipated and so that budgetary planning can be carried out on a more rational basis. Hopefully, the very valuable information on the prices and quantities of primary inputs used by industry developed by Statistics Canada will be made available to the research community in the near future.

To sum up: important priorities for improving Statistics Canada's productivity program include the following ones:

- The national balance sheet accounts need to be fully integrated with the productivity program. Statistics Canada collects information on 30 classes of assets with a detailed industry breakdown but publishes only a crude four type of asset by households, corporations and governments breakdown in the national balance sheets. The household sector needs to be split into a self employed

20 There are some difficult conceptual and practical problems involved in separating structure value from land value; see Diewert (2007a) for a discussion of some of these problems.

21 See Baldwin and Gu (2007) and Baldwin, Gu and Yan (2007) for descriptions of the Statistics Canada KLEMS program.

business component and a "consumer of goods and services" component and the corporate sector should be decomposed into industries with price and quantity information for the 30 classes of asset made available by quarter and by industry.

- The national balance sheet information on the value of land, residential structures and nonresidential structures needs to be greatly expanded so that more information on the *price* and *quantity* of real property by industry is made available. The problems associated with finding adequate constant quality price indexes for residential and nonresidential structures are formidable[22] but given the importance of real property in the Canadian economy, it is necessary to put additional resources into this area of economic measurement.
- The KLEMS program has developed very useful price and quantity information on 56 types of labour used by the Canadian business sector. But this information has only been made available in a highly aggregated form with information on only three types of labour service. It would be extremely useful for the more detailed information to be made available to the general community. If it is felt that the disaggregated information is not reliable enough to be released in this form, then it should be aggregated up and released at some level of detail that is more detailed than the present three price and quantity series. Furthermore, corresponding information on disaggregated labour input by type of worker should also be provided for the nonbusiness sector.[23]
- More information on the incidence of taxes needs to be provided in the input-output accounts, i.e. we need to know exactly in which cell of the input-output accounts various indirect and direct taxes are applied. Not only is this information required to reconcile final demand indexes with production accounts indexes, it is also required in order to evaluate the efficiency of our tax system.[24]
- Diewert (2008) shows that over short periods of time, changes in the real price of exports and imports can have substantial effects on living standards. However, due to the lack of data on imports used and exports produced by industry, his analysis applied only to the aggregate business sector. In order to extend Diewert's national methodology to the industry level to show the effects of changes in the terms of trade by industry, it will be necessary to expand existing input-output tables to include information on exports produced and imports used by industry.[25] Government departments who have an interest in productivity measurement by industry will have to consider whether it would be worthwhile extending the production accounts in this direction. These extended accounts would enable researchers to study issues related to outsourcing and globalization in a more scientific manner.
- Baldwin and Gu (2007:15-22) have a useful discussion about many of the unresolved issues in constructing an appropriate user cost formula in order to price capital services and note that an unambiguous "best practice" measure has not yet emerged. Given this state

22 For a review of these problems, see Diewert (2007a).

23 Statistics Canada has been a pioneer in developing and publishing very detailed information on the prices and quantities of outputs produced and intermediate inputs used by industry back to 1961 in its input-output tables. What we are asking here is that these tables be extended to also cover the 56 types of labour input and 30 types of capital input that are being used in the Statistics Canada KLEMS program. Note that extending the input-output tables to cover primary input allocations will also involve extensions to the corresponding final demand accounts, which in the case of inputs, will be corresponding household and government supplies of labour and capital.

24 See Diewert (2001; 97-98) for an elaboration of this point.

25 Diewert (2007b and 2007c) explains these expanded production accounts in more detail.

of affairs, we recommend that Statistics Canada provide not only the actual user costs by asset and year that they used in the KLEMS program, but that they provide supplementary information on the various ingredients (interest rates, property taxes, business taxes, asset price appreciation terms and asset prices) that go into the making of the user costs so that researchers can construct their own preferred versions. Eventually, a view will form on what the "best practice" user cost is, but we are not at this point yet and hence it is essential that Statistics Canada provide analysts with information on the various components of user costs.

The above recommendations are for the short run. In the longer run, Statistics Canada should also undertake research on the role of resource depletion, infrastructure capital, and intangible capital and develop preliminary data bases in these areas.

Conclusion

From the list of problems that were discussed above, it can be seen that we are some distance away from being able to accurately measure the productivity performance of individual sectors of the economy due to difficulties in constructing real input-output tables with appropriate detail for primary inputs.

In view of the magnitude of the measurement tasks ahead, it seems reasonable that we provide more resources to statistical agencies so that they can better measure economic growth, welfare and the productivity contributions of industry to improving welfare. On the other hand, it seems necessary that statistical agencies and international organizations concerned with economic measurement provide governments and the public a well thought out plan for improving economic measurement in coming years.

Academics and economic consultants can also play a role in improving economic measurement by providing practical methodologies to address difficult measurement problems.

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