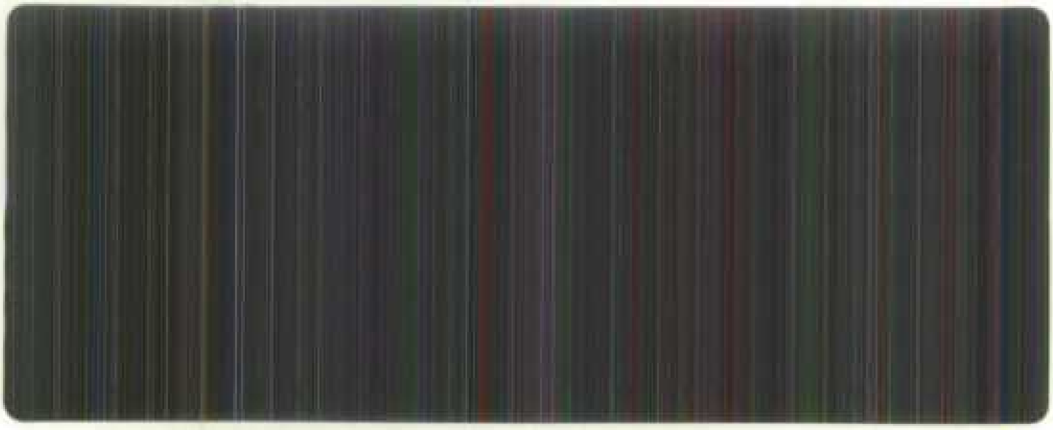
Input-output Division



Technical Series

Statistics Canada Statistique Canada

Canada

Input-Output
Technical Series

The Input-Output Division Technical Series are intended for users interested in input-output tables and related research for analysis and applications. Readers of the series are encouraged to contact the authors with comments and suggestions. A complete list of the titles that have been released appears at the back of this paper.

Papers in the series are distributed to Statistics Canada Regional Offices and Provincial Bureaus of Statistics. The series appears in the "Listing of Supplementary Documents" (11-207). A complete set is also maintained in the Statistics Canada Library and is available for consultation.

To obtain the list of titles and/or an individual paper, please contact:

Consulting and Marketing
Input-Output Division
Statistics Canada
23rd Floor, R.H. Coats Building
Ottawa, Ontario, K1A 0T6
(613) 951-3697

Statistics Canada
National Accounts and Analytical Studies
System of National Accounts
Input-Output Division

Double-Deflation and the Canadian Experience in Measuring Real GDP

By

M. Salem, N. Miller and Y.M. Siddiqi

75-E

August, 1994

DOUBLE-DEFLATION AND THE CANADIAN EXPERIENCE IN MEASURING REAL GDP[*]

by

M. Salem, N. Miller, and Y. M. Siddiqi

Abstract *The paper begins with the analyses which have questioned the concept and validity of real value added and the double-deflation technique used to compile real industry GDP. It provides a brief survey of the literature on these issues and the alternatives which have been advanced over the years to replace either the economic concept or the measurement technique. Finally, it describes Statistics Canada's experience in modeling and compilation of industry real value added to highlight how the shortcomings of double-deflation are managed in the Canadian input-output accounts.*

1. Introduction

Gross domestic product (GDP) is arguably the most often quoted of economic statistics and a premier example of how economic concepts influence every day decisions of businesses, individuals and governments. Real industry GDP obtained by the double-deflation technique is important because, as discussed below, it measures the contributions of members of an industry to the overall economy's output in real terms. This makes real industry GDP the most basic and indispensable measure of economic activity for an industry.

In Canada, the publication of industry GDP has a long history. Industry GDP and industry gross output[1] have been derived as integral parts of input-output accounts since 1979. In both current and constant prices, input-output

---

[*] An earlier version of this paper was presented at the 23rd General Conference of the International Association for Research on Income and Wealth, St. Andrews, N.B., Canada, August 21-27, 1994. Authors would like to thank Stewart Wells, Kishori Lal, Claude Simard and George Kitchen, all of Statistics Canada, for constructive comments on an earlier draft of this paper. Authors benefited from discussions with John Kendrick, Jack Triplett and Allan Young as well as T. K. Rymes for which they are grateful. Ideas expressed in this paper represent those of the authors and do not necessarily reflect the views of Statistics Canada.

[1]. Although the 1993 System of National Accounts uses the term "output", we use the commonly used term "gross output" to distinguish it from "net output" which is often used to refer to real value added.

tables have been published for the 1961 to 1991 period. This situation has offered a tremendous advantage for the analysis and estimation of real GDP by industry, and has afforded a valuable experience in the application of the double-deflation method.

Double-deflated real value added was first proposed by Solomon Fabricant in a study of the United States manufacturing from 1899 to 1937 for the National Bureau of Economic Research (See Fabricant 1940). The first estimates of real product originating in an industry consistent with national income and product concepts were published in 1951 by John Kendrick (See Kendrick 1951). The 1968 United Nations report, *A System of National Accounts*, placed a good deal of emphasis on constant price accounts. It provided explicit guidelines for compilation of industry value added in constant prices by means of double-deflation (See UN 1968, p. 57). Subsequent United Nations work on the system published in 1979, and recommendations for a revised SNA in 1992, have been explicit and forceful in supporting the compilation of real industry value added and the technique of double-deflation.

Although real GDP has been discussed and used extensively for a long time, the question of how it *should be* defined and measured is by no means free of controversy. Critical comments and analyses have concerned two distinct issues: the *concept* of industry GDP or real value added (RVA)[2] and the *technique* predominantly used to calculate it, namely double-deflation. In the 1960s and the early 1970s, the soundness of real GDP statistics published by statistical agencies as well as the validity of the concept of real value added were questioned in a number of articles; it was even suggested that constant price value added should be abandoned as an invalid concept.

Concerning the measurement of real value added, problems with index numbers were pointed out as early as Fabricant's own seminal study. He cautioned that double-deflation can lead, in rather uncommon circumstances, to a negative figure for a particular industry when nominal value added is itself positive. He hinted that this "reflects the ambiguity inherent in all index numbers

---

[2]. In the Fabricant study, real value added was also referred to as the net physical output and the net volume of output of industry. The terms "value-added" and "gross domestic product", in either price base, are used interchangeably in this paper, although some authors differentiate them.

of production and prices"(1940, Ch. 2, fn. 5). What drove these analyses was the possibility that a negative real value added could be obtained when the Laspeyres volume index number was used, but the criticism was often directed at the conceptual validity of expressing value added in constant prices. These criticisms induced Sato (1976) to comment that 'This [index number] inadequacy has cast a serious doubt on the quality of quantum and price indexes of real value added obtained by applying this method. This bred skepticism about the theoretical validity of the concept of real value added..." (p. 434).

Although the concept of real value added has been the subject of sporadic controversy over the last 30 years or so, no synthesis of the theoretical and empirical issues relating to real value added has emerged. This paper attempts such a synthesis and concludes that industry GDP statistics obtained by the double-deflation technique are both theoretically valid and empirically reliable.

The paper is organized as follows. Section 2 offers a brief survey of issues which have appeared in the literature. Section 3 examines the alternatives which have been advanced to replace the technique of double-deflation, their validity and relevance to the System of National Accounts. Section 4 describes Statistics Canada's experience in estimation of real industry GDP using double-deflation, together with an illustration of the most extreme case of estimation difficulties in Statistics Canada's input-output tables. The final section presents a summary and some concluding remarks.

2. The Trouble with Real Value Added: A Survey

As indicated above, the earliest publications of real value added (RVA) measures were for U.S. manufacturing (Fabricant, 1940) and for agriculture (Kendrick, 1951). The theme which motivated Fabricant's work on real industry value added was the examination of long term changes in the volume of output of the manufacturing sector (see, e.g., pp. ix-xii). It was essential to introduce a measure which avoided double counting of intermediate commodities traded

among manufacturing industries. When Fabricant presented the double-deflated value added results for U.S. manufacturing, he wrote

> "The ideal index of the net physical output of an industry would measure the changes in the aggregate value of net output attributable exclusively to changes in the physical quantities of the final products and to changes in the quantities of the materials and other commodities consumed in the fabrication of the final products, with prices of final products and of commodities consumed kept constant". (p. 25, original italics)

He then presented the Laspeyres quantity index number formula, with industry inputs in base year prices subtracted from outputs in base year prices. Since that presentation, this formula has been perceived as virtually identical to double-deflation. Similarly, the gross national product originating in U.S. farming in constant prices was presented for the first time by Kendrick and Jones (1951). They noted that

> "While 'gross' of capital consumption, it is net in the important sense that there is no double counting of products raised by farmers, or purchased from other industries, for use in further farming production". (p. 13)

The fact that it avoided double-counting was perhaps the main purpose of this formulation, but it carried the highly convenient aggregation property that it added up to the corresponding measure of output for the economy when added across industries. As in current prices, the constant price RVA by industry would sum to the gross product of the economy without double-counting of intermediate inputs. Fabricant (1940, p.26) noted, for instance, that 'For purposes of combination, then, the ideal index of output of an industry is an index of net output". Subsequent work by Kendrick and Jones on U.S. farming mindfully and explicitly placed the industry RVA concept within the framework of national income and product accounts so that the calculated real output was fully consistent with national income estimates.

The *raison d'être* of this measure as a national product and income accounting tool is clear in the original presentations. There was no suggestion in these works, or in Geary (1944), that industry value added in constant prices was to be an all-purpose output measure, or that it was in most respects superior to the traditional concept of real industry gross output. On the contrary, Geary (1944, p. 225) explained that

> "It is suggested that both series of index-numbers should be computed for each industry, the gross index to show the 'visible' quantum of goods available, and the net index to show the amount of work done in the industry." (original italics)

Fabricant (1940, p. 26) explained at length that

> "...if we wish to study the relation between the output of an industry and the input of materials, labour, equipment, etc.--which is indeed one of our ultimate objectives--the appropriate concept is gross output...On the other hand, if we wish to obtain an aggregate of the output of several industries, another objective of the present study, net output is the preferred measure. For net output is free from all duplication."

Notwithstanding what these originators explained about the nature of real value added in contrast to the real gross output, it was increasingly used for a wide range of purposes. Over the next few decades, real value added became the most common measure of industry "output" in statistical and economic analysis, including the burgeoning field of econometric analysis. It should be noted that statistical agencies in Canada and the U.S. regularly published only real value added measures for industries, although many researchers constructed series such as industry real gross output to better suit their own analytical needs.

2.1 The Concept of Real Value Added

An interesting but problematic feature of the literature on RVA is that the concept and the measurement technique of real value added were introduced simultaneously and remained indistinguishable for some time. The unobservable quantum, and the formula proposed to measure it, were presented together in

both Fabricant's book (1940, p. 25) and Geary's paper (1944, p. 256). The distinction between the two emerged later in papers by Sims (1969) and Arrow (1974).

The oversight to distinguish the concept from the technique became more evident with the publication of subsequent research. One of the earliest criticisms came from David (1962) who questioned the conventions used at statistical agencies, in the United States and in Canada, for deflating value added. The focus of his concern was the index number problem which presented the possibility that double-deflation could produce zero or negative values for RVA while the nominal industry value added is positive:

> “the appearance of a zero or a negative number as the constant dollar estimate may be quite disturbing: the mind boggles momentarily at the thought of zero or negative real flows associated with existing industries” (p. 149).

While it pointed out (1962, p.140) that these outcomes are “merely the symptom of a fundamental index number problem raised by the Fabricant-Geary deflation procedure”, namely, that the measurement technique was not adequately robust, it did not suggest improvements in the estimation technique. Instead, the paper suggested that “the difficulties inherent in the residual deflation method constitute a strong argument in favour of the alternative familiar approach to real national product [of calculating it] directly from the expenditure side” (p. 154)3. However, this would only yield a total value-added for the economy. To estimate industry RVA, David (1962, p. 154-5) suggested a different concept, namely, to deflate the incomes earned by capital and labour by consumption price indices faced by each party. In effect, it suggested an alternative concept when the technique seemed to fail in measuring the original concept satisfactorily. In a

---

[3]. The fact that real industry value added is computed *residually* cannot in fact account for zero or negative values if nominal value added is positive. Sato (1976) showed that when the nominal value is positive, the Paasche index of real value added is necessarily positive.

subsequent paper (discussed in Section 3), David (1966) presented yet another concept for real industry value added.

The best known response to these criticisms, and to the perception that real value added was crudely empirical with little or no theoretical justification, came from Sims (1969). The paper showed that a real value added index can be defined for any production function provided that the relevant primary inputs (taken to be capital and labour) are separable from others, namely material inputs. More importantly, it showed that under the common assumption of first degree homogeneity of the production function, double-deflation can yield a Divisia index of RVA by simple chain linking of index numbers. This formulation would also deal with the negativity problem but, more importantly, illustrated for the first time the grounding of real industry value added in economic theory.

One of Sims' important contributions in this brief paper was to focus attention on the "sensibility" of the concept of real industry value added. By showing that RVA is a valid neoclassical output concept only when the separability requirement is met, Sims showed by implication that RVA may not be meaningful without separability, no matter how calculated. In other words, using an RVA index to measure output only makes economic sense when the separability condition is satisfied. Whether production functions with these characteristics "exist" for certain industries became the subject of numerous research projects and publications, some of which are listed in the references at the end of this paper.

Finally, Sims argued that even when the conditions necessary for real value added to be an output concept (i.e., separability and first degree homogeneity) are met, it would not be valid for productivity measurement if it were calculated by double-deflation. This is because when real value added is calculated residually, all productivity are incorporated in value added (and none is attributed to intermediate inputs), so that analysis would be valid only under the

unusual condition that technical change is value added-augmenting and does not originate from intermediate inputs. This meant that factor productivity measures are biased even when the theoretical conditions are satisfied4. In spite of this warning, much of the productivity research in the following two decades continued to use real value added to measure industrial output, partly because these series were more easily available than real gross output data, especially for international comparisons.

An early assessment of constant price value added appeared in Rymes (1971) which devoted an entire chapter to the concept of net output. This chapter focused on inconsistencies in the concept of net output given by real value added and "advocated the use of gross output as the relevant and meaningful measure of sector output..." (p. 160). It confirmed that value added in current prices is fundamental and meaningful, but found that "To express net output in constant base-period prices is merely to create a fictitious measure of output with no meaning". (p.156) Rymes (1971, Ch. 7) appears to be the earliest argument that questions the validity of real value added *as a net output concept* independently of an index number problem which was the core objection of earlier literature.

Rymes examined analytical inconsistencies in the concept of net output (rather than final output) when constant price value added is used to measure the output of an open economy or an industry[5]. He illustrates this inconsistency at the industry level by analysing what happens to this "output" as technical progress

---

[4]. For further discussion of estimates of this bias, see Star (1974) and Bruno (1978).

[5]. For a better appreciation of these arguments the reader is referred to sections 4 and 5 of Chapter 7 titled "On the Concept of Net Output". Rymes identifies two problems in the open economy case–one dealing with imported consumption goods, and one with imported intermediate goods–when the foreign producing nation enjoys a higher rate of technical change than the home country and results in a lower relative price for these goods at home. However, he finds that only the case of trade in intermediate goods constitutes a serious flaw in the net-output concept.

makes some intermediate input less expensive in a gross production function framework. The analysis may be summarized as follows. Take industry A, which purchases intermediate input X from industry B. If the supplier of X experiences more technical progress than the rest of the economy, the cost of X in A's production function would fall relative to other intermediate and primary factors. This will result in A substituting in favour of X to maintain a profit maximum. Real gross output would increase by the product of the output elasticity of X and the increased use of it. In the new equilibrium, a higher gross output/value added in real terms would emerge because real gross output would have risen more than real value added. In an extreme case, the quantity of primary factors can remain fixed while only the quantities of the input in question would rise in response to the lower price so that real gross would register an increase whereas real value added would be unchanged. These differing movements between gross output and net output cannot be explained by production theory *if*, that its, what is measured by real value added is a net output index. Rymes finds these results unreasonable because the industry's real value added does not register an increase from the productivity of primary inputs even though they now work with more intermediate inputs. It argues that the real net output concept is not valid because of the way technical progress is incorporated into the neoclassical production function[6]. It is important to note that the analysis assumes that real value added corresponds to the net output side of a net production function. As such, it shows that movements in real value added can be inconsistent with what neoclassical production theory requires for a net output index based on a net production function. In this sense, Rymes criticism of a net output concept and the conclusions reached in this paper are consistent.

---

[6]. He concludes that "The basic fault with the net-output measure is that it seeks to isolate technical change in the sector in which it arises" (p. 159).

An important paper by Kenneth Arrow (1974) also addressed the meaning of real value added. Arrow also identified the separability of inputs in the production and cost functions as the key issue. He wrote

> "The notion of real value added has meaning in a production function only if this relation can be assumed to take on the special nested form $Q = Q[V(K,L),M]$" (p. 4)

here the symbols refer to industry gross output, capital, labour and material inputs, respectively, all in real terms. This would mean that "We can think of producing real value added from capital and labour...and then producing output from real value added and materials..." (p. 9). He showed that if this separability condition and constant returns to scale is assumed for the production technology, "The equation of any isoquant can be inferred from data on input quantities and input prices alone" (p.5). In other words, only if adequate observations existed on input prices and quantities alone, one could construct a quantity index of real value added without having to deflate any variables. In effect, Arrow showed that RVA is *independent of the deflation technique*, and that it can be measured without reference to real gross output. Using duality relations, he also showed that this can be done for the price index of real value added, which could be used to deflate nominal value added in a subsequent step. These conclusions are important because they show that RVA and the double-deflation technique are analytically separate and that their properties should be investigated separately.

Arrow's analysis supplied even more insight. Although the paper was titled "The measurement of real value added", it began by stating

> "The concept of "value added" has played an essential role in both private and national income accounting, *as a device for allocating the origins of income to the various points in the productive sector of the economy* at which primary factors are brought to bear on the creation of the total value of final products" (p.3, emphasis added).

It recognized the role of industry RVA as the means of distributing total real income to its productive origins, namely to industries. The paper would investigate whether real value added is meaningful in an additional sense. On what that was, he wrote

> "I will argue first that the most natural meaning, indeed the only one I can think of, arises from the estimation of production functions" (p. 4).

In other words, for real value added to be meaningful within a production function framework, where it is the output of the (net) production process, the separability condition is necessary. He concluded that "Without the separability assumption, however, it is hard to assign any definite meaning to real value added..."(p.5).

Berndt and Christensen (1973) has rather profound implications for the practical relevance of these conclusions, although the paper does not deal directly with real value added. Among other questions, the paper deals with rather precise definitions of separability of functional forms and what they imply for partial elasticities of substitution among inputs. Their findings imply that in order for a function to be separable in the sense discussed above (weak separability), the partial elasticity of substitution between pairs of factors must be the same. This would mean that if a certain type of capital and a certain type of material input are substitutes, that type of capital and energy input must be substitutes (to the same extent) as well. This is problematic, because in many industrial conditions we would expect that energy and certain capital equipment to be complements. Many authors have commented that the substitutability requirement is so stringent that it makes the existence of separability implausible[7].

Sato (1976) undertook a thorough examination of the subject to "clarify what real value added really measures and how it is to be measured" (p.435). His work was at least partly motivated by the negativity problem which, he wrote, "...bred skepticism about the theoretical validity of the concept of real value added

---

[7]. See, for instance, the discussion in Diewert (1978).

and led even to a proposal for its abandonment" (p.434). The paper shares a perspective with Arrow (1974) in acknowledging that real value follows from the need to maintain the identity between total expenditure on final goods and services and the sum of value added by industries which holds in current prices. Furthermore, that as the United Nations recommended the use of Laspeyres index to compute gross national or domestic expenditure for the System of National Accounts, an equivalent procedure (i.e., double-deflation) is applied at the industry level for consistency. The paper goes on to enquire what it is that real value added measures8. He finds that

> "Part of the problem is conceptual. Since value added sums up to GNE, i.e., the aggregate of final products, one would be tempted to interpret it as a measure of output, namely, net output created by primary inputs over and above the materials put into the production process."(pp.434-5, emphasis added)

In contrast to Arrow's analysis which asked if real value added is meaningful as an output of a net production function, Sato argues that it is "valid" in a different way. He shows that the real value added index is the quantum index of primary inputs for any differentiable production function if the unit price of material inputs is equal to their value of marginal product--a condition which holds under profit maximization. Most importantly, the validity of real value added as an inputs index does not depend on separability. If production is subject to constant returns to scale, then this relationship would hold exactly; when increasing returns to scale holds, the real value added index is the product of the index of primary inputs and the returns-to-scale coefficient; and the converse would hold for decreasing returns. The paper concludes that

> "The real value added index, then, is the product of the quantum index of primary inputs and intangible economies of scale. Thus, real value added is the contribution of tangible and intangible primary factors of

---

[8]. The paper also reviews various statistical formulations of real value added, and finds that a Divisia formulation avoids the perverse negativity problem of the Laspeyres index.

> production. *It is more appropriate to consider it as an intermediate product than visualizing it as some sort of final output.* In any event, real value added is a valid concept. So is the implicit value-added deflator" (p. 436, emphasis added).

Sato (pp. 437-440) also shows that the *true* index of real value added (which is also a Divisia index) is bounded from above by the Laspeyres index and from below by the Paasche index, and can be defined but would be unique only if material inputs and primary factors were separable in a homogeneous production structure. This is consistent with the results obtained by others earlier. Once again, the paper emphasizes that these conditions do not affect the validity of real value added as an aggregate of primary inputs which can be measured through alternative index number formulations and, when correctly measured, is non-negative (pp. 439-441).

Another paper which dealt with separability and the existence of real value added functions was Bruno (1978) which addressed the same questions, but used a technically different approach. Using a hybrid value added function which combined primal and dual components, it asked whether calculated value added in constant prices can be shown to be a function of primary inputs and their own marginal productivities (measured by value added). He finds that this is contingent on one of three conditions: intermediate inputs must either remain a fixed proportion of output, their relative prices must remain constant or, as already shown by Sims and Arrow, the production technology must be separable between intermediate materials and primary inputs. These findings expand the results presented by Sims to a multi-input case.

A very different approach was taken by Diewert (1978). Unlike the papers discussed so far which focused on the separability condition, it examines the problem from the point of view of aggregation by analogy to Hicks' Aggregation Theorem. The paper notes that virtually all empirical studies which use a production function use real value added data as their output index, rather than real gross output data. It asked specifically how this "substitution" of real value added in place of real gross output can be justified in empirical work. The paper presents and proves a theorem that a real value added function is a well

behaved neoclassical production function only if the prices of outputs and intermediate inputs vary proportionately. If this condition were satisfied, he concludes, ‘the substitution of deflated value added for real output can be justified from the point of view of empirical production function studies” (p.36). This is a powerful finding because if prices moved proportionately the production function *need not be separable* for real value added to be useful for analysis of production. Diewert adds, however, that ‘it is extremely unlikely that this last condition has been satisfied in any western industrial economy during the past twenty-five years” (p.41). He explains that this is because the price of energy grew little in the pre-1973 period compared to produced goods so that, in relative terms, the desired proportionality did not hold. One may reason that Diewert`s reasoning applies with equal force to the following decades as the prices of microprocessors and computer-related goods declined relative to other industrial production.

Concurrent with the research discussed so far a wider recognition emerged, particularly in production and productivity research, that valid use of RVA as an output measure was conditional. Specifically, it was recognized that to meet the neoclassical criteria[9] for being the output of a net production function, it was necessary to meet either the weak separability or the price proportionality conditions. Theoretical advances of the early 1970s, such as flexible functional forms and the econometric techniques to use them in empirical work, provided the needed tools for testing these hypotheses, rather then taking them as maintained hypotheses. The required conditions for the “existence” of a real value added index were statistically tested by a number of researchers using Canadian and U.S. real value added data. These studies commanded a great deal of interest in the 1970s because real gross output was generally not available from statistical agencies and real value added was extensively used for analysis[10]. In Canada, real industry gross output statistics were published as part of the first input-output tables in constant prices in 1979. Most studies statistically tested a form of

---

[9]. For an outline of the conditions for a well behaved neoclassical production function see Diewert (1978). It suggests, however, that these conditions are not necessary for econometrically estimating the parameters of the industry's production technology.

[10]. Some empirical research was conducted with real gross output data before such measures were published by statistical agencies. These studies constructed their own gross output time series by deflating the nominal series by industry selling price indices which were generally available for manufacturing industries.

separability or price proportionality using Canadian or U.S. real value added data and found that neither hypothesis could be supported. In the United States, the results were first published by Berndt and Wood (1975) who tested both the Hicks aggregation theorem and the separability hypothesis using data for US manufacturing for the 1947-1971 period. They rejected both hypotheses (as well as the more traditional Leontief aggregation hypothesis). In Canada, Denny and May (1977) tested and rejected both hypotheses using Statistics Canada data on Canadian manufacturing industries for 1950 to 1972. Many other studies, of which a few are cited in this paper, examined the same hypotheses and generally made the same conclusions[11].

2.2 Double-Deflation of Value Added

While the economics literature in the 1960's and 1970's reflected analysts' concerns with properties of RVA, national accountants became more concerned with proper interpretation and use of real GDP statistics. International guidelines on national accounting, later known as the System of National Accounts, were first issued by the United Nations in 1953 and then revised in 1969. These guidelines did not elaborate fully on analytical properties and potential uses of these measures. The latter document (UN, 1969) discussed nominal value added thoroughly, but its coverage of *real* value added was merely technical and geared to operationalizing these measures. A possible reason for this is that production theory and econometric techniques for parameter estimation which intensively use this data were in more formative stages. In the early years, real industry value added was used predominantly for what it was intended, namely, to gauge the net contribution of industry to the overall real product, economic growth, changing industrial mix and overall inflation. This

---

[11]. See, for instance, Fuss (1977) and Denny and May (1978) for Canada, and Yuhn (1991) for the United States.

situation had changed significantly by the 1970s and national accounting practitioners were more explicit about what real value added was, and what it was not. For instance, the 1979 UN guidelines devoted explicit discussion to the meaning of real value added:

> "The origins of the concept of value added lie in the desire to avoid attributing to an industry that part of the value of its output which consists of the value of goods and services produced by other industries..."
>
> "Value added is intended as a measure of the contribution of an individual enterprise, or group of enterprises such as an industry, to the total output of goods and services produced by all enterprises together." (UN SNA, 1979, p. 49-50, emphasis added).

In Canada, industry real value added is derived within the framework of constant price input-output accounts by double-deflation, as the accounting entry which balances industries' outputs and intermediate inputs in base year prices[12]. Double-deflated value added is defined as the difference between total deflated industry gross output and total deflated industry intermediate inputs including taxes and subsidies (leading to GDP by industry at factor cost).

Problems associated with real value added fall into three general streams. These are outlined below. The most persistent criticism directed at this procedure is that when a Laspeyres quantity index number is used, as is common, it can sometimes generate a negative real value added when nominal value added is positive. These extreme cases are more problematic for fixed-base indices, such as those used by Statistics Canada, especially when data years are far removed from the base year. In these cases, current period actual profit maximizing input

---

[12] This approach is confined to the business sector of the Canadian economy. The real output of transactors which are classified to the government sector and to the personal sector are not obtained by double-deflation, since estimates of "output" in prices of the base year are often unattainable. Contributions to real GDP of these transactors are estimated with rather imperfect measurement techniques suitable to each case. These techniques are discussed in Statistics Canada (1987 b).

mix is so far removed from what prevailed in the base year that, in prices of the base year, intermediate input costs are more than the income from gross output. This is an index number problem aggravated by a fixed base system of prices. As Sato (1976, p. 435) showed, double-deflation with the Paasche index always produces non-negative results and approximations to the Divisia index are likely to do so as well. Empirically, it is effectively dealt with by chain-linking (if a Laspeyres index number is preferred), or by performing double-deflation with a superlative index number formula. The revised SNA's recommendation also calls for superlative index numbers, preferably in chain-linked form. However, over the years, some critics have made the erroneous conclusion that problems with the index number technique imply an inconsistency in the *concept* of RVA. This has led to proposals for alternative measures which are based on entirely different concepts of RVA.

The second measurement problem was pointed out by Geary (1944, p. 258) and by Sims (1969, p. 471), namely that when double-deflation is used, real value added is measured with the cumulative of output measurement errors and input measurement errors, and that this is particularly problematic when value added is a small proportion of gross output. This remains one of the significant drawbacks of double-deflation. Although the mean of industry GDP would not be biased, the larger variance of the estimator can produce relatively large fluctuations in time-series unless extraneous industry information and additional estimation techniques are used. Clearly, an estimator with a variance smaller than the sum of those for intermediate inputs and gross outputs is preferable, provided that it is unbiased.

The third problem was outlined by Sims (1969, p.471): Double-deflation calculates real value added residually and this means that all technical progress is attributed to primary inputs making it inappropriate for productivity analysis. Technical progress leads to lower input levels for a given level of output and/or a

higher level of the latter for the same basket of inputs (including primary factors). In other words, all types of technical progress can result in changes in the quantum indices of outputs, intermediate inputs and primary inputs. The residual technique of netting out the quanta of intermediate inputs from those of gross output would incorporate into real value added all productivity gains which resulted in output increases, and those which resulted in input savings[13]. When double-deflated value added is subsequently used *as an output index* in a multifactor productivity exercise, the results would be biased.

This would be an undesirable property if real value added were an appropriate output measure, i.e., if either of the conditions for the existence of a value added function could reasonably be expected to hold. However, since we have seen that RVA is ***not*** an output measure in the production theory sense, it is not certain that this is a weakness. On the contrary, this is a necessary and desirable feature for deflation of industry GDP. Movements in the index of aggregate net output of the economy, its real GDP, include all productivity gains no matter where in the economy they may occur. An important property of any deflation technique for industry value added is to incorporate all gains within the industry's boundaries due to technical change into the real value added figure, otherwise the national accounting identity in constant prices would be violated. Residual calculation of real value added is the only deflation technique which incorporates all such gains into real industry GDP[14].

Guidelines of the System of National Accounts do not often specify the microeconomic basis of their recommendations. However, the guidelines on value

---

[13]. This is in fact one of the drawbacks of labour productivity measures because they overstate the true gains in productivity of labour input.

[14]. The gains discussed here are gross productivity gains, i.e., the difference between real output and real intermediate use, including positive or negative gains due to scale economies or other systematic (e.g., net technical progress) or random factors.

added in constant prices are clearly consistent with the points raised in this paper about the theoretical aspects of RVA:

> "Within an integrated set of price and volume measures such as those relating to the flow of goods and services in the use matrix or an input-output table, gross value added has to be measured by double-deflation method. Otherwise, it will not be possible to balance uses and resources identically." (UN 1992, p.21).

and

> "Another way of looking at this phenomenon is to recognize that value added is an accounting balance which is defined in such a way as to ensure that the sum of the value of intermediate inputs plus value added is identical with the value of gross output. ... In general, balancing items are accounting constructs which are only defined and measurable within the theoretical framework provided by some system of accounts." (UN SNA, 1979, p. 50).
>
> "Whatever set of prices is used, a measure is needed of the contribution of an individual enterprise, or group of enterprises, to the total output of goods and services produced within an economy." (UN SNA, 1979, p. 51).

3. Alternatives to Double-Deflation of GDP

This section will examine proposals which have appeared in the literature as alternatives to the existing measures of real value added. The Section does not cover the multitude of proxies and techniques which have been used when there is not adequate data for the double-deflation approach. A thorough discussion of these approaches can be found in Hill (1971).

The earliest alternative formulation was probably in the paper by David (1962) discussed earlier, where it was suggested informally that real gross (national or domestic) product for an economy should be compiled from the expenditure side of the accounts rather than by double-deflation and, for an industry, double-deflation should be replaced by an approach which would measure the real product-equivalent of the incomes earned by the primary factors. It suggested that

> "Assuming that the factors employed in a given industry spend their received income on final demand goods and services, the income originating could be deflated directly with an index reflecting the prices which the factors of that industry paid in making their final demand purchases." (p.154)

Whatever the merits of this alternative, it was abandoned by the author when he formally proposed another alternative index in a subsequent paper (David, 1966). In this paper, David pointed out that it was important to measure real value added in order to attribute the economy's gross product to its originating industries, the "contribution" made by individual industries. He suggested that "one can define a measure of net output that would represent the industry's physical output corrected to exclude the contribution to physical output made by inputs purchased from other industries". Following this intuitive reasoning, he showed that if intermediate inputs used in a production process are evaluated at their marginal product to the using industry, and if they are removed from an industry's real gross output, this would be equivalent to a process of deflating the industry's value added by the price index of its gross output[15]. Thus, David's suggestion was to deflate the nominal industry value added by the prices of its own products, in contrast to double-deflation which implicitly would use a combination of input and output prices. However, the paper acknowledged that this deflation technique does *not* measure the net contribution of the industry to total real GDP unless it was also subject to constant returns to scale, and noted that the double-deflation technique does not hinge on this assumption in measuring the industry's net contribution. David also showed some properties of the proposed measure, such as its potential biases when the necessary assumptions do not hold, as well as very simple and intuitive aggregation properties.

---

[15]. This would also assume parametric output and input prices as well as the usual neoclassical production function conditions.

In a later article, Hansen (1974) argued that "...there is no contradiction between the double-deflation method and David's single-deflation method. They answer different questions and are relevant for different purposes" (p.415). He illustrated that when nominal value added is deflated with the price index of industry gross output, the resultant constant price value differs from double-deflated value added by exactly the gain or loss the industry would encounter as a result of changes in its "terms of trade", or the change over time in the ratio of its own price compared with the prices it pays on its intermediate purchases. When aggregated across industries to obtain gross domestic product, David's measure would differ from double-deflated GDP by an international "terms of trade" entry. Hansen suggested that "It might even be argued that this is the virtue of his index" (p. 415).

A few comments should be made about the David measure. First, David (1966) did not deal with how technical progress is accounted for at the industry and at the aggregate level. This is an important failing since an industry's contribution to the gross product depends not only on the primary inputs it employs, but also its productivity change over time. Second, the paper predates the more rigorous discussion which took place following the analysis in Sims (1969) and Arrow (1974) which deal with the conditions necessary for an index to be an "output" measure. As a result, there is no literature on how properties of David's measure compare with double-deflated real value added in terms of indicating real industry net output. Third, as Fenoaltea (1976, p. 128) pointed out, because the price index applied to nominal value added is a function solely of the final output of the industry, David's measure would be dependent on the degree of vertical integration in the industry which differs arbitrarily among industries[16]. Finally, since this measure redefines only the price of industry value added while leaving the prices of gross output and intermediate inputs in tact, it would not conform to a constant price accounting framework (real inputs and real value added do not add up to real output).

---

[16] For instance, when two industries are separate, the value added for each would be deflated by its respective production price so that an average of the two prices would effectively apply to the combined industry. However, when the two industries are integrated vertically, the same nominal combined value added would be deflated with the price of the final stage of production.

In a comprehensive paper, Fenoaltea (1976) introduced a fully specified alternative to real industry value added. The paper is candid about advancing a different concept of real value added, outside of the existing theoretical and accounting frameworks. The theoretical basis for the proposed measure can be gleaned from the following[17]

> "The first purpose of a real value added measure, however, is to reduce all production to the same unit, so that it is all directly comparable...On all these grounds, it would appear, the best index of real value added may be a simple deflation of current values added by the current value of common labor'" (p.112)

> "The essential objective of the desired real value added measure is to render *all* industrial production directly comparable, regardless of differences in time (or space) or technique, by expressing it in the same, unchanging unit of value.
> On the other hand, no specific deflator stands out as *the* theoretically correct one: there is no all-purpose standard of value, and no particular standard is defined by the desire to construct meaningful intertemporal comparisons of industrial production. In practice, then, an arbitrary choice is inevitable; ... Of all the things that may thus be taken as the standard of value, perhaps the best is labour, in the specific sense of ordinary physical effort (whose price thus excludes the return to human capital or compensation for particularly painful working conditions)." (p. 122)

And,

> In the case of contemporary economies amply documented by their statistical bureaus, of course, one might simply deflate current values added by some official index of prices. Among these, the most attractive would appear to be the GNP deflator: since industries would then be measured in 'real' terms essentially by distributing 'real GNP' among industries in proportion to their share of GNP at current prices, 'real values added' would happily sum to 'real GNP'" (p. 123).

---

[17]. Additionally, Fenoaltea finds that there is "obvious cause to question the established practice of identifying the limits of an industry with those of particular firms" (p. 113). He finds that deflation should not be particular to an industry itself, but rather be more general and uniform (e.g., use a uniform standard of real value, regardless of the activity being evaluated). On this point, he claims that "There is some recognition in the literature that 'real' measures should reflect relative price as well as quantity, and thus that *own-price deflation is inappropriate...*" (p. 121, n.25, italics added)

Although the paper is quite extensive, it does not examine analytical properties of the measure or how it would fit in with other frameworks such as national accounting and production or cost analysis which are the prevailing bases for growth accounting and productivity analysis.

After outlining some criteria for characterizing an ideal class of real net output, Fenoaltea presents a numerical simulation which compares alternative output measures, including the double-deflated index, and his own measure which deflates output by the price of labour. His simulation uses a CES production function assuming that labour is the *only* primary factor and that no significant technical progress occurs. The simulation results and the measure itself were critically analyzed in a later paper by Sims. In this paper, Sims (1977, p. 128) showed that Fenoaltea's output measure is not analytically superior to the other measures and, in fact, leads to anomalous results under quite reasonable circumstances. For instance, where the industry does not purchase any intermediate inputs so that real value added and real gross output are the same by all standards, all alternative measures show the same output except the Fenoaltea measure. Sims also argued that if the Fenoaltea approach were to measure both an industry's real primary inputs, and its real net output, as claimed, then it is necessary that it shows the same index when it compares two identical vectors of primary inputs at different points in time or in different places. However, this is not the case as a rule: using either the labour or the GNP price, the same primary inputs can be assessed differently. Fenoaltea (1977) responded that these results are not anomalous, but reflect the invariant standard of value which he proposes to use to measure value added and that "those conventional measures are in fact inappropriate" (p.133) [12].

It is evident from the foregoing that what is proposed by Fenoaltea is really a different notion of what an industry's real value added or its net output really is or should be. It is also evident that this may conflict with many fundamentals of the neoclassical and national accounting frameworks within

---

[12]. Fenoaltea (1977) explains in fact that his framework is distinct from that used by Sims: "His notions of real value added, real primary input, and real net output are therefore not equivalent to my notions of real value added, the real value of primary inputs (activity), and the real value of net output (the results of activity); what he proves for his categories proves nothing for mine". (p. 133)

which it is evaluated, because it is not intended to be a neoclassical concept. We can see this clearly in the context of industry productivity. Assume that an industry experiences technical progress, so that it produces more output in the current period compared to the last period with the same vector of inputs. The neoclassical framework is clear about this typical situation: all of the incremental production would be recorded in *both* real gross output and real double-deflated value added. In the Fenoaltea framework, at least some of the incremental output will *not* be recorded in real value added (while it will be part of nominal value added) when real wages increase in response to productivity growth.

Another alternative is proposed by Durand (1991). This alternative is built on the idea that unlike double-deflation where value added is deflated by a combination of the industry's own output and input prices, it would be deflated by the price index of the ultimate user of that industry's production, i.e., by the valuation of final users. The alternative approach, called "indirect deflation" by the author, is explained as follows:

> "One interpretation of the new method, therefore, is that it corresponds to the direct deflation method applied to the direct and indirect uses of primary inputs. Extending the method to many industries with complex interindustry transactions leads one to *deflate the primary input costs of industries by the gross output price of the last industries using them*" (p. 5, italics added)

In other words, nominal value added is deflated by the production price index of the industry which ultimately sells the fully processed product or service to final users. Assuming that there are no taxes or other elements separating the price at the factory gate (the "producer price") and what the final user pays, this would be the price of the final good or service, such as the widely published consumer price indices and investment price indices[12]. However, the interpretation of the pricing

---

[12]. We can illustrate the pricing scheme with an example. For an industry manufacturing loaves of bread, real value added would be obtained by deflating the nominal value added by the price index of its own gross output if it is sold as a final good directly by the manufacturing industry. In this case, the method is identical to that suggested by David (1966). If the industry's output is sold to, say, the retail trade industry which in turn sells it to final users, then the price index for the gross output of the retail trade industry would be used to deflate the value added of the manufacturer. Finally, if bread is sold through a more complex chain, say first to wholesale trade industry, then to the restaurant industry and then to the final user, it would be the price

scheme--the theoretical basis for this method--only applies to the single product case, where only one good or service output is produced per industry. The reason is as follows. When an industry produces two or more goods, one cannot associate the industry's value added with a particular final good or final user unless either the intermediate or the primary factors used to produce each product were known (a "commodity technology" input-output table with no economies of joint production). In this case, one would have a distinct production technology, in effect a pseudo-industry, for each good of each industry. Since this information is not available, one is forced to assume that value added (and intermediate inputs) can be apportioned to the production of various goods on the basis of the share of each good in the industry's total gross output. This is only possible if the production function met another "separability" condition, i.e., the separability of outputs from inputs. Much like the separability condition discussed earlier, this is a very stringent assumption, demanding that all goods are produced with an identical technology (see Hall (1973)). The separability assumption is implicit in this technique because it utilizes square technological input-output relationships derived from a rectangular input-output table with many inputs and many outputs.

From an operational point of view, the technique used by Durand (1991) is a very straightforward application of the input-output inverse matrix to constant price values[20]. The ingredients needed are 1) an input-output table for the economy on an annual basis which can produce a reliable inverse matrix from current price data and 2) data on final expenditures by commodity in constant prices (i.e., for consumption, investment, government expenditure and net exports) which are independently reliable (i.e., do not depend on a constant price input-output table). The proposed measure is then computed as follows: First, final expenditures in constant prices by commodity are transformed to the industry space; this is done by assigning a basket of final goods and services to industries according to industries' share in total supply of each commodity. Second, this

---

index for the gross output of the restaurant industry which would deflate the value added of bread manufacturing. In all three cases, it is the final user's valuation of goods and services (given by the consumer price index) which is used to assess the manufacturer's contribution to real GDP.

[20]. In fact, the method is best summarized in one equation by the author (equation 8 in the text) as the product of 4 input-output matrices.

vector (industry length) is multiplied by the input-output inverse to answer the following question: "how much real *gross output* can one associate with this level of real final use for each basket of goods and services?". Finally, these estimates of industry real gross output are multiplied by the value-added/gross output ratio of that industry in current prices. The result is a vector which allocates total real GDP over all industries according to the system--or relative shares--of real final expenditures. Durand (1991, p.4) states this as follows:

> "Hence, the difference between the double-deflation and the alternative method relies in the distribution of total real value-added between industries. The double-deflation technique distributes total real value added to industries according to their base year relative prices while the new method distributes real value-added according to the new relative prices".

On the question of properties of the proposed measure compared to the traditional measure, the paper cites "better statistical and analytical properties than those obtained with the double-deflation method" (p. 1). The three statistical advantages cited for this method can be summarized as follows: First, "the alternative value-added price index proposed here, being a weighted average of final demand prices, is, by construction, always positive..."(p. 11). And, second, that these prices are "completely insensitive to the share of nominal industry value-added into gross output" (p. 11), which makes the time trend of industry GDP prices more stable. The proposed measure clearly has these properties because its industry GDP prices are not a function of industry variables (unless that industry sells directly to final users). The third statistical advantage listed is that "it requires only final demand commodity prices" (p. 11), and this is an advantage because price indices for intermediate goods and services are often difficult to define and costly to collect. It seems true that this method needs much less data collection and processing compared to the traditional method, but it should also be noted that, commensurate with less data use, the measure imparts less industry information to the user.

On the question of analytical properties, the paper shows that a decomposable productivity growth can be formulated for the new measure which sums to what is usually defined for traditional measures. It also shows that, using the proposed method, the notion of industry productivity growth would conform to Passinetti's definition of so-called "vertically integrated industries".

Two salient points can be concluded from the above discussion. First, it is quite evident that these proposals do not offer alternative techniques for measuring real value added, but that each suggest, sometimes inadvertently, an alternative to the concept of real value added of Fabricant, Geary and Kendrick. It is not surprising that there are alternative ways of looking at an industry's contribution to the total product of an economy. As Lal (1982) has pointed out,

> "GDP is not an observable phenomenon. It is a concept, a model. It is not a unique reality because it is not independent of the assumptions and conventions made and used by the investigator" (Lal, 1982, p.29)

It is this lack of uniqueness which permits the multitude of models based on different points of view. However, this would hinder comparisons between countries, and even comparisons between investigators within each country. It is perhaps for these reasons that international guidelines aimed at comparability of practices have been provided by the United Nations since the early 1950s.

Second, as we showed in Section 2, real value added was not introduced into the literature as a measure of the net output of primary factors of a net production function. However, real value added was often erroneously used by analysts in this capacity, in effect substituting a net production relationship for a gross one. Proposed alternatives which are predicated on the failure of RVA to be a good substitute for real gross output must demonstrate that they have the analytical properties of the output of a net production function. Proposals reviewed above fail to address this point entirely.

4. The Canadian Experience with Double-Deflation

In the Canadian System of National Accounts (CSNA) double-deflation is used to estimate real value added for industries in the business sector, and the main tool for accomplishing this is the input-output accounts. These accounts consist of three matrices, two of which, the Make and Use matrices, record the transactions of the business sector. The Make matrix records commodity outputs of each industry, while the purchase and use of intermediate and primary inputs are found in the Use matrix. The third matrix, the Final Demand matrix, is also required to analyze, adjust and balance the whole system. Double-deflated industry GDP is obtained as the difference between the industry's deflated gross outputs and deflated intermediate inputs inclusive of net indirect taxes.

The most important set of deflators is for outputs by commodity. A large majority of these deflators (78%) are based on price indexes, mainly industrial product price indexes (IPPI), but also include machinery and equipment price indexes (MEPI), raw material price indexes (RMPI), farm input price indexes (FIPI) and consumer price indexes (CPI). A lesser number (9%) are unit value indexes based on quantity and value data from production surveys and other sources; about 3% are based on indexes of average weekly earnings of employees (AWE). The remainder consists of several types, including indexes from other divisions in the CSNA, indexes based on base year or averages of base and current year rates, implicit price indexes of inputs of the industry producing the commodity or deflators constructed from fees and rates available in administrative documents and industry publications. For more complex commodities--such as many business services, financial services, banking and insurance--economic models are used which make use of these price series, as well as price and quantity information from a variety of sources, to develop appropriate deflators.

The input-output deflation process begins by deflating industry outputs, recorded in the make matrix, with a set of output deflators--one for each commodity. In the final demand matrix, special deflators are also used to deflate many imported commodities, but output deflators are used where no import deflators are available. Exports are deflated with domestic output deflators, but

there are special export deflators for 20 of the more important export commodities. Intermediate use and other final uses are deflated with a weighted index of domestic (output less exports) and import prices. Where commodities are nearly homogeneous, a single price deflator is applied to all production and uses of the commodity (evaluated at producers prices). However, for commodities which are heterogeneous in either production or use, specific deflators are developed and applied to each individual case while maintaining a balance between the total supply and total use of the commodity in constant prices. For instance, special deflators, classified by commodity and industry of purchase, are constructed for the deflation of machinery and equipment commodities.

While much effort is spent on developing deflators of the highest quality, scrutiny and analysis of the deflation of input-output tables are more substantial parts of the process. Input-output tables are completely balanced and because the flows through industries and final demand categories are inter-related they are examined simultaneously. On the industry side, the analysis consists in summarizing the performance of each industry, at the worksheet level of detail, by examining certain selected aggregates, and the relationships and trends based on these aggregates, and setting up methods of analysis for the detection of outliers. Each industry is first reviewed individually, then in relation to those upstream and downstream from it. The aggregates analyzed include gross output, intermediate inputs, goods inputs, services inputs, energy inputs, net indirect taxes, and gross domestic product at factor cost. These are examined in current and constant prices together with implicit prices. This is supplemented with information on employment by industry so that labour productivity indicators can also be analyzed. Summary statistics and diagnostic tools are used to locate problems which can affect the quality and reliability of results. They are used, for instance, to detect whether there are shifts in the series due to changes in product mix or product type. It is important to ensure that such a shift is also reflected in price deflators so that current and constant price movements are consistent. On the input side, if a change in production technology or in the type of inputs is discovered, it is examined to ensure consistency between the current and constant prices. Any detected phenomenon, whether statistical or economic, is scrutinized

to ensure that is symmetrically reflected on both the input and the output vectors, in both the current and the constant prices.

The deflation procedure outlined here is applied annually to estimate real output, real input and real GDP for 209 industries which make up the Canadian input-output tables at the worksheet level. Together with the analysis and the quality control stages which follow, the procedure yields very satisfactory results without inordinate estimation difficulties. For a few industries, however, double-deflation as an automatic estimation technique must be supplemented with further work to ensure satisfactory estimates. In Canada, the most extreme problems for double-deflation occur in the Refined Petroleum industry. This is why it has been chosen as an example for this paper.

4.1 The Refined Petroleum Industry: An Example

The petroleum refining industry in Canada has a number of structural features which make the estimation of outputs, inputs and GDP of the industry particularly difficult. An important difficulty lies in the industry structure of the petroleum production activity in Canada[21]. In this activity, establishments in some of the upstream activities such as extraction, those engaged in the refining activities and many of those located further downstream in the distribution and marketing activities are owned by the same enterprises. This situation demands that different operations conducted by the same companies in different establishments be classified to industries with very different input-output technologies. This involves allocating values between two or three industry classifications. For instance, all inputs, whether raw materials or financial services, must be estimated on an establishment basis for each industry and

---

[21] . The concept of an industry as a collection of establishments, rather than an activity, is clear and well entrenched in national accounting. For instance, the 1993 SNA repeats that "Thus, output is a concept that applies to a producer unit--an establishment or enterprise--rather than a process of production." UN (1993, p.127, Para. 6.38).

ultimately removed from gross output to obtain industry value added. This task is further complicated by transactions between establishments belonging in different industry classes not being arms-length transactions. This can be a particular problem for segregating refining operations from other activities.

In addition, the petroleum refining industry is characterized by relatively small value added compared to gross output when measured in factor cost in current prices. In 1986, the base year for constant price accounts, GDP at factor cost made up about 12% of gross output with the remainder being accounted for by intermediate input costs and net indirect taxes of the industry. In both current and constant prices, this ratio has remained relatively small throughout the time span of Canadian input-output tables. This feature of the industry by itself makes accurate estimation of GDP difficult no matter which method is used. It should be noted that in these cases the production value of the industry, which is much larger than its GDP, overstates the proportions of the problem in GDP estimation. The industry's relatively small real GDP figures correctly indicate the extent of any estimation problems.

The difficulty which is specific to the double-deflation technique was well summarized by Sims (1969, p. 471). He pointed out that since residually computed real value-added is an external average, the impact of year to year variations in the industry's gross output would produce variations in real GDP which are many times larger. Variables such as production and its price index are typically measured with a statistical error. Even if such errors have a zero mean and a small variance, it is straightforward to see that separating out a small part of the total will impose a cost in terms of a larger variance. The variance of the value added portion extracted from a gross production estimate can be genuinely reduced only if additional information were used. Mechanical techniques which smooth out these variations do not improve the quality or reliability of the results. In estimating this industry's input-output structure, it was decided not to eliminate

the variability of real GDP by smoothing it with one of the known techniques. The procedure followed is to analyze each year's variation in double-deflated GDP (from the previous year or from a trend, when one exists) and to identify the sources of variation in the estimated output and input vectors. When detected variations are due to measurement errors (e.g., inexact timing, price heterogeneity, inconsistent coverage between price indices and corresponding commodity values, etc.) corrections are made to improve estimates based on the information gathered during the exploration. There are no international guidelines for dealing with data imperfections and quality control problems of this type. Some measurement errors exist in all data series. However, in error-sensitive cases such as this industry, they are more easily revealed and provide an opportunity for improvement. The remaining variations in the real GDP are left as they are, with the series showing relatively larger variance around trend compared to the industry's own real gross output.

Another factor which aggravates estimation problems in this industry is that the breakdown of the industry's commodity outputs at the factory gate is not precisely known. For example, it may not be possible to determine at that point the final allocation of fuel between diesel, which is used in the operation of vehicles and machinery, and light fuel oil, which is used for heating. The exact commodity breakdown may depend on the downstream marketing stage. This may result in a less reliable average price for the industry's gross output if the usual deflation procedure is followed where a price index is used to deflate the production of each commodity in current prices. In this situation, it was determined that projecting base year values by quantity series would yield very high quality estimates of production in constant prices. The output of this industry consists of a number of homogeneous goods for which very reliable quantity and quality data are available. Unlike other industries, an integrated report of production quantities are available for all members of the industry.

Together with data on quality change (e.g., the switch towards unleaded gasoline) a high quality estimate of output in constant prices is prepared. This approach has proven much more robust than the price deflation technique and yielded more satisfactory time series for the industry's real gross output and real GDP. Hence, while price deflation is not applied for the output side of this industry, the double-deflation technique is still found most appropriate to obtain real industry GDP.

5. Summary and Concluding Remarks

Our review of the literature showed that originators of double-deflated real value added did not intend to replace the proper measure of real industrial activity, namely, real gross output. It was intended rather as an measure of the contribution of industries to real gross (national or domestic) product of industrial complexes which could avoid duplication.

From the 1950s through the 1970s, many analysts used real value added statistics as an "output" corresponding to "inputs" of primary factors, even though such a relationship (a net production function) has never been shown to exist empirically. The availability of these statistics, and the relative difficulty of obtaining real gross output measures, may explain this substitution. This may also explain why real GDP was used for productivity measurement when it was shown in the 1960s to be unwarranted even if a net production function did exist.

The review showed that analytical *use* of real GDP as an output index, or to measure industrial productivity, has been questioned for many decades in both theoretical and empirical literature. It concludes that to be a valid measure of net output, the output of primary factors alone, the measure must meet either the separability criterion or the price proportionality criterion. It is generally accepted in the literature that, *a priori*, these analytical conditions are very unlikely to occur and are contrary to industrial reality. Empirical research has supported this point repeatedly, rejecting the existence of an index which could represent the "output" of primary inputs for an industry.

These works do not question, however, the validity or meaningfulness of real GDP, no matter how calculated. In fact, Kazuo Sato has shown that there is

a solid theoretical basis for real GDP, not as an output index, but as an index of tangible primary inputs and intangible productive efficiencies gained within the industry. This is the same concept which underlies real GDP for the economy. There is general agreement in the theoretical and national accounting literature that this is an appropriate index of the contribution of industries to total real GDP. However, many authors have shown that there are index number problems in existing industry statistics. The United Nations recommendations for the revised System of National Accounts has addressed these problems and suggested practical solutions to them.

The paper also reviewed alternatives proposed in the literature. It found that they are not alternatives to the double-deflation approach to measure real value added, but rather alternatives to the accepted concept of real GDP. They propose, in effect, what industry real GDP *should be*, rather than offering better ways of deflating nominal GDP within the national accounting framework. The review showed that the most central criticism in the literature is that real value added is not a consistent measure of "net output" according to the neoclassical theory of production. Alternatives proposed to replace real value added are then looked at to meet the criteria for such a meaningful net output concept. The proposed measures discussed here do not deal with and do not meet these criteria.

REFERENCES

Arrow, K. J. "The Measurement of Real Value Added", in P.A. David and M. W. Redder (eds.) ***Nations and Households in Economic Growth***, New York, Academic Press, 1974, pp. 3-19

Ansmits, A. "Quantity and Price Measures for Business Services: The Case of Engineering and Architectural Services" ***Mimeograph***, Voorburg Group on Services Statistics, Ottawa, October 1989

Berndt, E. R. and Christensen, L. R. "The Internal Structure of Functional Relationships: Separability, Substitution and Aggregation" ***Review of Economic Studies*** Vol. 40, No. 3, 1973, pp. 403-10

Berndt, E. R. and Christensen, L. R. "Testing for the Existence of a Consistent Aggregate Index of Labour Inputs" ***American Economic Review*** June 1974, pp. 391-404

Berndt, E. R. and Wood, D. O. "Technology, Prices, and the Derived Demand for Energy" ***Review of Economics and Statistics*** August 1975, pp. 259-68

Blackorby, C. Primont, D. and Russel, R. R. "On Testing Separability Restrictions with Flexible Functional Forms" ***Journal of Econometrics*** 5, 1977, pp. 195-209

Bruno, M. "Duality, Intermediate Inputs and Value-Added" in Fuss, M. and McFadden, D. (eds.) ***Production Economics: A Dual Approach to Theory and Application*** Vol. 2, Amsterdam, North-Holland, 1978

Corden, W. M. "Effective Protective Rates in the General Equilibrium Model: A Geometrical Note" ***Oxford Economic Papers*** Vol. 21, No. 2, 1969, pp. 135-41

David, P. A. "The Deflation of Value Added" ***Review of Economics and Statistics*** Vol. 44, 1962, pp. 148-55

David, P. A. "Measuring Real Net Output: A Proposed Index" ***Review of Economics and Statistics*** Vol. 48, 1966, pp. 419-25

Denny, M. and May, D. "The Existence of a Real Value-Added Function in the Canadian Manufacturing Sector" ***Journal of Econometrics*** Vol. 5, 1977, pp. 55-69

Denny, M. and May, D. "Homotheticity and Real Value-Added in Canadian Manufacturing" in Fuss, M. and McFadden, D. (eds.) ***Production Economics: A Dual Approach to Theory and Application*** Vol. 2, Amsterdam, North-Holland, 1978

Diewert, W. E. "Hicks' Aggregation Theorem and the Existence of a Real Value Added Function" in Fuss, M. and McFadden, D. (eds.) ***Production Economics: A Dual Approach to Theory and Application*** Vol. 2, Amsterdam, North-Holland, 1978

Domar, E. "On the Measurement of Technological Change" ***Economic Journal*** Vol. 60, 1961, pp. 709-29

Durand, R. “An Alternative to Double-deflation for Measuring Real Industry Value-Added” ***Mimeograph**, Input-Output Division, Statistics Canada*, 1991

Fabricant, S. ***The Output of Manufacturing Industries, 1899-1937*** National Bureau of Economic Research Inc., New York, 1940

Fenoaltea, S. “Real Value Added and the Measurement of Industrial Production” ***Annals of Economic and Social Measurement*** Volume 5, No. 1, 1976, pp. 111-137

Fenoaltea, S. “Real Value Added Once Again” ***Annals of Economic and Social Measurement*** Volume 6, No. 1, 1977, pp. 133-134

Fuss, M. A. “The Demand for Energy in Canadian Manufacturing” ***Journal of Econometrics*** 5, 1977, pp. 89-116

Geary, R. C. “The concept of Net Volume of Output, With Special Reference to Irish Data” ***Journal of the Royal Statistical Society*** Vol. 107, 1944, pp. 251-261

Geary, R. C. “Reflections on National Accounting” ***Review of Income and Wealth*** Vol. 19, 1973, pp. 221-251

Hansen, B. “A Proposed Real Net Output Index: A Comment” ***Review of Economic and Statistics*** Vol. 56, 1974, pp. 415-16

Hansen, B. “Double-deflation and the Value Added Product: Comment” ***Review of Economic and Statistics*** Vol. 57, 1975, pp. 382-83

Hall, R. E. “The Specification of Technology with Several Kinds of Output” ***Journal of Political Economy*** Vol. 81, No. 4, 1973

Hill, T. P. ***The Measurement of Real Product*** Organization for Economic Cooperation and Development, Paris, 1971

Kendrick, J. W. ***Economic Accounts and their Uses*** McGraw-Hill Book Co., New York, 1972

Kendrick, J. W. and Jones, C. E. “Gross National Farm Product in Constant Dollars, 1910-50” ***Survey of Current Business*** Vol. 31, pp. 13-19, Sept. 1951

Lal, K. “Gross Domestic Product” ***Canadian Statistical Review***, Statistics Canada, Ottawa, April 1982

Lal, K. “Compilation of Input-Output Tables: Canada” ***Review of Income and Wealth***, December 1982, pp. 411-30

Lal, K. “The Revised U.N. System of National Accounts vis-à-vis the Canadian System of National Accounts” **Mimeograph**, System of National Accounts, Statistics Canada, 1992

Rymes, T. K.	***On Concepts of Capital and Technical Change*** Cambridge University Press, London, 1971
Sato, K.	"The Meaning and Measurement of the Real Value Added Index" ***Review of Economic and Statistics*** Vol. 58, 1976, pp. 434-42
Sato, K.	"Double-deflation and the Value Added Product: Comment" ***Review of Economic and Statistics*** Vol. 57, 1975, pp. 382-83
Sims, C.	"Theoretical Basis for A Double Deflated Index of Real Value Added" ***Review of Economics and Statistics*** Vol. 51, Nov. 1969, pp. 470-71
Sims, C.	"Remarks on Real Value Added" ***Annals of Economic and Social Measurement*** Volume 6, No. 1, 1977, pp. 127-31
Statistics Canada	***Deflation of the Input-Output Accounts*** Forthcoming, Catalogue 15-601 E Ottawa
Statistics Canada	***Input-Output Structure of the Canadian Economy 1961-1981*** Catalogue 15-510 Ottawa, 1987 (a)
Statistics Canada	***Input-Output Structure of the Canadian Economy in Constant Prices 1961-1981*** Catalogue 15-510 Ottawa, 1987 (b)
Star, S.	"Accounting for the Growth of Output", ***American Economic Review*** March 1974, pp. 123-35
Stone, R. & Prais, S. J.	"Systems of Aggregative Index Numbers and their Compatibility" ***Economic Journal*** Vol. 62, 1952, pp. 565-83
United Nations	***A System of National Accounts***, Studies in Methods, Series F, No. 2, Rev. 3, United Nations New York, 1968
United Nations	***Manual on National Accounts at Constant Prices***, Series M, No. 64, United Nations, New York, 1979
United Nations	***Revised System of National Accounts***, Provisional, Series F, No. 2, Rev. 4, United Nations, New York, 1992
Usher, D.	"The Suitability of the Divisia Index for the Measurement of Economic Aggregates" ***Review of Income and Wealth*** Vol. 20, 1974, pp. 273-288
Yuhn, Ky-Hyang	"Functional Separability and the Existence of Consistent Aggregates in U.S. Manufacturing" ***International Economic Review*** Vol. 23, No. 1, Feb. 1991

TECHNICAL SERIES/CAHIERS TECHNIQUES

INPUT-OUTPUT DIVISION/DIVISION DES ENTRÉES-SORTIES

STATISTICS CANADA/STATISTIQUE CANADA

(1)
Hoffman, *et al.*, *User's Guide to Statistics Canada Structural Economic Models*, Input-Output Division, Statistics Canada, Revised September 1980.

(2)
Hoffman, *et al.*, *Guide d'utilisation des modèles économiques et structuraux de Statistique Canada*, Division des entrées-sorties, Statistique Canada, Révisé septembre 1980.

(3)
Durand, R., and Rioux, R., *Estimating Final Demand Expenditure at Factor Cost and Net of Tax Price Indices in the Canadian Input-Output Tables*, Paper Presented at the International Round Table on Taxes and the CPI, Ottawa, Input- Output Division, Statistics Canada, March 3, 1987.
Out of Print. Durand, R., and Rioux, R., *Estimating Final Demand Expenditure at Factor Cost and Net of Tax Price Indices* Now published in Economic Systems Research, Journal of the International Input-Output Association, Volume 6, Number 3, 1994. pp.265.

(4)
Siddiqi, Y., Murty, P.S.K., and Diena, J., *Highlights of the Public Sector Market Study, 1983*, Input-Output Division, Statistics Canada, September 1987.

(5)
Murty, P.S.K., *Size and Structure of the Public Sector Market, 1983, Sources and Methods*, Input-Output Division, Statistics Canada, September 1987.

(6)
Durand, R., *The Adding-Up Problem in the Computation of Aggregate Constant Price GDP*, Input-Output Division, Statistics Canada, October 1987. Out of Print/Epuisé

(7)
Durand, R., and Markle, T., *Measuring the Variability of Input-Output Structures: A Progress Report*, Input-Output Division, Statistics Canada, December 1987. Out of Print/Epuisé

(8)
Durand, R., and Markle, T., *On the Variability of Input-Output Structures: A Progress Report on the Constant Price Industrial Input Structures*, Input-Output Division, Statistics Canada, April 1988.Out of Print/Epuisé

(9)
Durand, R., and Markle, T., *Structural Change in the Canadian Economy: The Supply Side in Current Prices*, Input-Output Division, Statistics Canada, July 1988. Out of Print/Epuisé

(10)
Durand, R., *Statistics Canada's Price Model: A Detailed Description of the Structure and Simulation Capacities*, Input-Output Division, Statistics Canada, August 1988.

(11)
Durand, R., and Markle, T., *Structural Change in the Canadian Economy: The Supply Side in Constant Prices*, Input-Output Division, Statistics Canada, October 1988. Out of Print/Epuisé

(12)
Durand, R., and Markle, T., *A Diversity Analysis of Structural Change Based on the Canadian Input-Output Tables*, Input-Output Division, StatisticsOut of Print Durand, R. and Markle, T., *Diversity Analysis of Strutural Change Based on the Canadian Input-Output Tables*. Now published in Economic System Research, Journal of the International Input-Output Association, Volume 6, Number 3, 1994, pp.277

(13)
Durand,R. and Markle ,T., *Structural Change in the Canadian Economy: The Supply Side in Constant Prices*, Input-Output Division, Statistics Canada, October 1988. Out of Print/Epuisé

(14)
Murty, P.S.K..,Généreux, P.A., Leblanc D., and Grennberg, M., *Provincial Sales Tax Commodity Allocation Project, 1984 Sources and methods*. Input-Output Divisison, Statistics Canada, January 1989.

(15)
Durand, R., *The Balancing Process of the Regional Input-Output Tables*, Input-Output Division, Statistics Canada, February 1989. Out of Print/Epuisé

(16)
Siddiqi, Y., Murty, P.S.K., and Diena, J., *Highlights of the Provincial Sales Tax Commodity Allocation Project, 1984*, Input-Output Division, Statistics Canada, January 1989. Reprinted from Canadian Economic Observer, May 1989.

(17)
Durand, R., *Aggregation Formulas for Multifactor Productivity*, Input-Output Division, Statistics Canada, June 1989. Out of Print/Epuisé

(18-E)
Mercier, P., Durand, R., and Diaz, A., *Specification of Parameters for the National Input-Output Model*, Input-Output Division, Statistics Canada, December 1991.

(18-F)
Mercier, P., Durand, R., et Diaz, A., *Spécification des paramètres du modèle d'entrées-sorties national*, Division des entrées-sorties, Statistique Canada, décembre 1991.

(19-E)
Siddiqi, Y., and Murty, P.S.K., *Commodity Indirect Taxes in the Canadian Input-Output Accounts, 1984*, Input-Output Division, Statistics Canada, July 6, 1989.

(19-F)
Siddiqi, Y. et Murty, P.S.K., *Impóts indirects sur les biens et les services dans les comptes d'entrées-sorties du Canada, 1984*, Division des entrées-sorties, Statistique Canada, 6 juillet 1983.

(20)
Markle, T., *Progress Report # 5: On the Temporal Variability of the Aggregate Input Structure*, Input-Output Division, Statistics Canada, September 1989. Out of Print/Epuisé

(21)
Siddiqi, Y., and Murty, P.S.K., *Highlights of Commodity Taxes for 1984*, Input-Output Division, Statistics Canada, Canadian Economic Observer, September 1989.

(22)
Siddiqi, Y., and Murty, P.S.K., *Commodity Indirect Taxes - An Inventory before the GST*, Input-Output Division, Statistics Canada, Canadian Economic Observer, October 1989.

(23)
Murty, P.S.K., and Siddiqi, Y., *Government Expenditures on Goods and Services and Transfer Payments in Canada, 1961-1985*, Input-Output Division, Statistics Canada, December 1989.

(24)
Murty, P.S.K., and Siddiqi, Y., *Government Expenditures on Goods and Services anf Transfer Payments in Canada 1961-1985*, Input-Output Division, Statistics Canada, Reprint from Canadian Economic Observer, May 1990.

(25)
Siddiqi, Y., and Murty, P.S.K., *Commodity Indirect Taxes in the Canadian Input-Output Accounts, 1984-1986*, Input-Output Division, Statistics Canada, February 1990.

(26)
Durand, R., *Growth Accounting and the Quality Adjustment of the Capital Stock*, Input-Output Division, Statistics Canada, February 1990. Out of Print/Epuisé

(27)
Durand, R., and Salem, M., *On a Dynamic Productivity Index Number Formula*, Input-Output Division, Statistics Canada, revised version February 1990. Out of Print/Epuisé

(28)
Diaz, A., *The 1989 Increase in Labour Compensation per Person: Was it caused by wage demands?*, Input-Output Division, Statistics Canada, June 1990.

(29)
Murty, P.S.K., *Federal Goods and Services Tax and the Canadian System of National Accounts*, Input-Output Division, Statistics Canada, October 1990.

(30)
Effective tax rates and net price indexes/Les taux de taxe actuels et les indices de prix net, Feature Article/Etude spéciale, Canadian Economic Observer/L'observateur économique canadien, November 1990/novembre 1990.

(31)
Salem, M., *Documentation of Capital Input and Capital Cost time series for Multifactor Productivity Measures*, Input-Output Division, Statistics Canada, reviewed and updated by R. Fortin and Y. Sabourin, December 1990.

(32)
Siddiqi, Y., and Murty, P.S.K., *Federal Sales Tax in the Canadian Input-Output Accounts*, Input-Output Division, Statistics Canada, July 1989.
Draft. Out of Print.

(33)
Murty, P.S.K., *New Paradigm to Analyze Government Transfer Payments with special reference to Canada*, Input-Output Division, Statistics Canada, January 3, 1991. Draft

(34)
Durand, R., *Productivity Analysis and the Measurement of Gross Output Net of Intra-Industry Sales*, Input-Output Division, Statistics Canada, January 1991.

(35)
Murty, P.S.K., and Siddiqi Y., *A New Paradigm to Analyze Commodity Indirect Taxes and Subsidies, 1986-1989*, Input-Output Division, Statistics Canada, April 5, 1991.

(36)
Généreux, P., *The Input-Output Structure of the Economies of the Yukon and Northwest Territories, 1984*, Input-Output Division, Statistics Canada, May 1991.

(37)
Généreux, P., *La structure par entrées-sorties des économies du Yukon et des territoires du Nord-Ouest, 1984*, Division des entrées-sorties, Statistique Canada, mai 1991

(38)
Durand, R., *An Alternative to Double Deflation for Measuring Real Industry Value-Added*, Input-Output Division, Statistics Canada, June 1991.
Out of Print. Now published in Review of Income and Wealth, Series 40, Number 3, september 1994.

(39)
Généreux, P., *I/O Tables in constant prices: Revised deflation process and analysis of the machinery and equipment sector*, Input-Output Division, Statistics Canada, September 1984. Reprint July 1991.

(40)
Murty, P.S.K., and Siddiqi, Y., *Government subsidies to industries/Les subventions gouvernementales accordées aux industries*, Input-Output Division/Division des entrées-sorties, Statistics Canada/Statistique Canada, Reprint from Canadian Economic Observer/Réimprimé de l'observateur économique canadien, May 1991/mai 1991.

(41)
Diaz, A., *Alternative Concepts of Output and Productivity*, Input-Output Division, Statistics Canada, Catalogue 15-204E, 1989 issue; July 1991.

(42)
Durand, R., *Aggregation, Integration and Productivity Analysis: An Overall Framework*, Input-Output Division, Statistics Canada, Catalogue 15-204E, 1989 issue; July 1991.

(43)
Diaz, A., *The Statistics Canada Concepts and Measures of Productivity*, Input-Output Division, Statistics Canada, July 1991. Discontinued

(44-E)
Dionne, M., *Measuring Capital Depreciation*, Input-Output Division, Statistics Canada, July 1991. Discontinued

(44-F)
Dionne, M., *Mesure de la dépréciation du capital*, Division des entrées-sorties, Statistique Canada, novembre 1991. Discontinuer

(45)
Murty, P.S.K., and Siddiqi, Y., *Scope of Public Grants Economy in Canada*, Input-Output Division, Statistics Canada, December 6, 1991.

(46)
Murty, P.S.K., et Siddiqi, Y., *Portée de l'économie des subventions publiques au Canada*, Division des entrées-sorties, Statistique Canada, le 6 décembre 1991. Projet.

(47-E)
Gill, K., and Larose, M., *Sources and Methods of Estimating Employment by Input-Output Industries for the years 1961 to 1989*, Input-Output Division, Statistics Canada, November 1991, revised February 1993.

(47-F)
Gill, K., et Larose, M., *Sources et Méthodes d'estimation de l'emploi par industries entrées-sorties de 1961 à 1989*. Division des entrées-sorties, Statistique Canada, novembre 1991, révisé février 1993.

(48)
Murty,P.S.K., and Siddiqi, Y., *Transfer Payments in National Accounts and Grants Economics*, Input-Output Division, Statistics Canada, May 25, 1992.

(49)
Interprovincial and International Trade Flows of Goods 1984-1988/Flux du commerce international et interprovincial des biens 1984-1988, Input-Output Division/Division des entrées-sorties, Statistics Canada/Statistique Canada, June 1992/ juin 1992. Cost/Coût=$500.00. Out of Print/ Epuisé

(50)
Messinger, H., *Canada's Interprovincial Trade Flows of Goods, 1984-89/Flux du commerce interprovincial des biens au Canada 1984-1989*, Input-Output Division/Division des entrées-sorties, Statistics Canada\StatistiqueCanada, January1993/janvier1993. Forthcoming/A venir. Cost/Coût=$800.00

(51)
Webber, M., *Estimating Total Annual Hours Worked from the Canadian Labour Force Survey*, Labour and Household Surveys Analysis Division and Input-Output Division, Statistics Canada, April 1983.

(52-E)
Statistics Canada's input-Output Model: General description, Critical Analysis of Partially Closed Version and Alternative Solutions, Input-Output Division, Statistics Canada, June 1991.

(52-F)
Le modèle d'entrées-sorties de Statistique Canada: présentation générale,analyse critique de la version avec fermeture partielle et solutions de rechange, Division des entrées-sorties, Statistique Canada, juin 1991.

(53)
Murty, P.S.K., *A New Approach to Analyze Public Sector Grants: A Case Study of Canada*, Input-Output Division, Statistics Canada, January 1993.

(54)
Murty, P.S.K., *Scope of the Public Sector Grants in the Canadian Economy Revisited, Input-Output Division*, Statistics Canada,January 1993.

(55)
Murty, P.S.K., *A Blueprint for the System of Grant Accounts*, Input-Output Division, Statistics Canada, February 1993.

(56)
Murty, P.S.K., *The Need for a System of Grant Accounts*, Input-Output Division, Statistics Canada, March 1993.

(57-E)
Sidiqi,Y. and Salem, M.,*Estimating More Timely Input-Outputs Accounts; A Synthetic Approach*, Input-Output Division, Statistics Canada,March 1993.

(57-F)
Siddiqi, Y., et Salem, M., *Estimation des comptes d'entrées-sorties dans des délais raisonnables : une méthode synthétique*, Division des entrées-sorties, Statistique Canada, mars 1993.

(58-E)
Poole, E., *A Guide to using the Input-Output Model of Statistics Canada*, Input-Output Division, Statistics Canada, June 1993.

(58-F)
Poole, E., *Guide d'utilisation du modèle d'entrées-sorties de Statistique Canada*, Division des entrées-sorties, Statistique Canada, juin 1993, révisé le 18 octobre 1993.

(59)
Murty, P.S.K. *System of Grant Accounts. Input-Output Division*, Statistics Canada, September 1993

(60-E)
Allard-Saulnier, M., *Comparability of Multifactor Productivity Estimates in Canada and the United States*, Input-Output Division, Statistics Canada, Catalogue 15-204E, 1991 issue; February 1993.

(60-F)
Allard-Saulnier, M., *Comparabilté des estimations de la productivité multifactorielle au Canada et aux Etats-Unis*, Division des entrées-sorties, Statistique Canada, N^{0}15-204F au catalogue, issue 1991, février 1993.

(61-E)
Maynard, J-P., *Hours Worked: A New Measure of Labour Input for Multifactor Productivity Estimates*, Input-Output Division, Statistics Canada, Catalogue 15-204E, 1991 issue; February 1993.

(61-F)
Maynard, J-P., *Les heures travaillées: une nouvelle mesure de l'entrée de travail pour la productivité multifactorielle*, Division des entrées-sorties, Statistique Canada, N^{0}15-204F au catalogue, issue 1991, février 1993.

(62)
Murty, P.S.K., A *New Approach to Analyze Grants Economy*, Input-Output Division, Statistics Canada, October 21, 1993.

(63)
Messinger, H., *Interprovincial Trade Flows of Goods and Services/Les flux du commerce interprovincial des biens et des services*, Feature Article/Etude spéciale, Canadian Economic Observer/ de l'observateur économique canadien, October 1993/octobre 1993.

(64-E)
Durand, R., *Statistics Canada Multifactor Productivity Program,*. Based on "Le programme de productivité multifactorielle de Statistique Canada", Actualité Economique, Vol. 69 (4) décembre 1993, pp.313-330 and Feature Article, *In Measuring Agricultural Productivity and Related Data for Regional, National and International Comparisons Proceedings*, (S. Narayanan and J. King eds.), Agriculture Canada , 1994.

(64-F)
Durand, R., *Le programme de productivité multifactorielle de Statistique Canada,* Etude spéciale, L'Actualité économique, Revue d'analyse économique, vol.69,n04, Division des entrées-sorties, Statistique Canada, décembre 1993.

(65)
Murty, P.S.K., *1990 Public Sector Input Output Accounts for the Republic of Kenya*, Input-Output Division, Statistics Canada, December 1993.

(66)
Durand, R., *On the Measurement of Capital Services and Economic Efficiency*, Input-Output Division, Statistics Canada, September 1993, revised March and September 1994.Being Reviewed/en revue.

(67-E)
Durand, R., *The Canadian Productivity Accounts: Interpretation and Analytical Uses*, Input-Output Division, Statistics Canada, November 7, 1994.

(67-F)
Durand, R., *Les comptes canadiens de la productivité: interprétation et utilisations analytiques*, Division des entrées-sorties, Statistique Canada, le 7 novembre 1994.

(68)
Durand, R., *New Alternatives Estimates of Real Industry Value-Added for Canada*, Input-Output Division, Statistics Canada, December 1994.

(69)
Murty, P.S.K., EXECUTIVE SUMMARY *Hospital Data in the national Accounts*, Input-Output Division, Statistics Canada, December 22, 1994.

(70)
Murty, P.S.K., *Hospital Data in the national Accounts*, Input-Output Division, Statistics Canada, January 9, 1995.

(71-E)
Murty, P.S.K , *First Nations and Inuit in The Public Sector of The National Accounts,* Input-Output Division, Statistics Canada, May, 1995.

(71-F)
murty, P.S.K., Traitement de l'automonie gouvernementale des Pemières Nations et des Inuit dans le secteur des administrations publiques des comptes nationaux, Division des entrées-sorties, Statistique Canada, mai, 1995.

(72-E)
Murty, P.S.K and Siddiqi, Y., *Provincialization of the Government Sector in the Provincial Input-Output Accounts of Canada, 1990* , Input-Output Division, Statistics Canada, May, 1995.

(73-E)
Johnson, Joanne, *A KLEMS Database: Describing the Input Structure Canadian Industry*, Input-Output Division, Statistics Canada, Catalogue 15-204E, 1992 issue; April, 1994.

(73-F)
Johnson, Joanne, *Une base de données KLEMS: décrivant la structure des entrées de l'industrie canadienne,* Division des entrées-sorties, Statistique Canada, N^{0}15-204F au catalogue, issue 1992, avril , 1994.

(74-E)
Johnson, Joanne, *Analysing Canadian Manufacturing Using the KLEMS* Input-Output Division, Statistics Canada, Catalogue 15-204E, 1992 issue; April, 1994.

(74-F)
Johnson, Joanne, *L'analyse des industries manufacturières canadiennes à partir du KLEMS* Division des entrées-sorties, Statistique Canada, N^{0}15-204F au catalogue, issue 1992, avril 1994.

(75-E)
Salem, M., Miller, N.and Siddiqi, Y.M., *Double-Deflation and the Canadian Experience in Measuring Real GDP*, Input-Output Division, Statistics Canada, August, 1994

ORDER FORM

Input-Output Division

MAIL TO:
Publication Sales
Statistics Canada
Ottawa, Ontario, K1A 0T6

FAX TO: (613) 951-1584

A Fax will be treated as an original order. Please do not send confirmation.

(Please print)

Company ______________________

Department ______________________

Attention ______________________

Address ______________________

City ______________ Province ______________

Postal Code ______________ Tel. ______________

METHOD OF PAYMENT

☐ Purchase Order Number *(please enclose)* ______________

☐ Payment enclosed $ ______________

☐ Bill me later (max. $500)

Charge to my: ☐ MasterCard ☐ VISA

Account Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Expiry Date ☐☐☐☐

Signature ______________________

Client Reference Number ______________________

Catalogue Number	Title	Frequency/ Release Date	Annual Subscription or Book Price			Qty	Total $
			Canada $	United States US$	Other Countries US$		
15-201	System of National Accounts: The Input-Output Structure of the Canadian Economy, 1987	Annual 02/91	60.00	72.00	84.00		
15-204E	System of National Accounts: Aggregate Productivity Measures, 1989	Annual 07/91	40.00	48.00	56.00		
15-510	System of National Accounts: The Input-Output Structure of the Canadian Economy, 1961-1981	Occasional 01/88	66.00	79.00	79.00		
15-511	System of National Accounts: The Input-Output Structure of the Canadian Economy in Constant Dollars, 1961-1981	Occasional 01/88	66.00	79.00	79.00		

Version française de ce bon de commande disponible sur demande

Catalogue Number	Title	Frequency/ Release Date	Annual Subscription or Book Price			Qty	Total $
			Canada $	United States US$	Other Countries US$		
	CORPORATE PUBLICATIONS						
11-001E	The Daily	**Daily**	120.00	144.00	168.00		
11-002E	Infomat	**Weekly**	125.00	150.00	175.00		
11-008E	Canadian Social Trends	**Quarterly**	34.00	40.00	48.00		
11-010	Canadian Economic Observer	**Monthly**	220.00	260.00	310.00		
11-204E	Statistics Canada Catalogue 1990	**Annual**	13.95	16.70	19.50		

	SUBTOTAL	
Canadian customers add 7% Goods and Services Tax.	**GST (7%)**	
Please note that discounts are applied to the price of the publication and not to the total amount which might include special shipping and handling charges and the GST.	**GRAND TOTAL**	

Cheque or money order should be made payable to the Receiver General for Canada/Publications. Canadian clients pay in Canadian funds. Clients from the United States and other countries pay total amount in US funds drawn on a US bank.

Order completed by: Date:

Subscriptions will begin with the next issue.

For faster service ☎ **1-800-267-6677** ☎ **VISA and MasterCard Accounts**

**PF
0347
05/90**