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THE SNA93 VALUES AS A CONSISTENT FRAMEWORK FOR PRODUCTIVITY MEASUREMENT: UNSOLVED ISSUES

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The SNA93 as a source of a consistent set of values for productivity accounting is studied. In the valuation of intermediate inputs and outputs the main problems relate to the treatment of taxes and subsidies on products. In labor share the main problem is the separation of the labor compensation of the self-employed. As to the value of capital input, the exact relationship between depreciation, efficiency decline and obsolescence is missing in the SNA93. All relevant assets are not allocated to industries. Treatment of the services of financial intermediaries is also problematic

1. INTRODUCTION

In the neoclassical growth accounting framework the rate of productivity growth is measured by the difference of the rate of change of combined output and that of combined input. For this a full set of volume and price accounts for outputs and inputs are needed. A necessary condition for having a complete set of volumes and prices is to have a complete set of values. The rates of change of individual inputs/outputs are aggregated to the rates of change of combined input/output using the respective value shares. These values have to be determined in a set of accounts that is internally coherent and gives a consistent description of the production process. The exact specification of the accounting framework is however often overlooked in productivity accounting, the most notable exception being the work done by Dale W. Jorgenson and his associates (see e.g. Jorgenson, 1995a, 1995b; Jorgenson, Gollop, and Fraumeni, 1987, referred to as JGF from now on). A considerative amount of work to improve the comparability of the measurement both of productivity and of productivity growth has been performed over decades, most recently by the OECD (2001a) in its excellent productivity manual. An alternative to the neoclassical approach are the Harrod-Rymes (1971) measures, which take into account the producibility of capital input. Cas and Rymes (1991) give a detailed exposition of the theoretical basis and of the empirical application of these measures.

The System of National Accounts 93, referred to as SNA93 (ISWGNA, 1993) provides a consistent set of accounts that aims at international comparability. The sheer physical magnitude of the volume gives a good idea of how much detail is actually needed to define such a framework. Therefore it does not seem sensible

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to build a separate sequence of accounts for productivity measurement. But productivity analysts often find the SNA93 in some respects unsuitable for this purpose (see e.g. Diewert, 1996; Hulten, 1996) and suggest it should be revised to serve it better. In this paper problems connected with the SNA93 accounts as a source of a consistent set of values for productivity measurement are discussed. For this it is necessary to specify what kind of requirement the theoretical bases of TFP-measures set, either explicitly or implicitly, for the data on the values of inputs and outputs used to calculate these measures. The aim of this paper is to find out whether the SNA93 meets these requirements, and if not, whether it is because these requirements are impossible to meet in a representation of a real economy

The methodological framework of productivity accounting, with which SNA93 is compared, is outlined Section 2 of this paper. It consists mainly of the KLEMS-framework introduced by Jorgenson and Griliches (1967) and developed further, for example in JGF (1987). This framework seems to be prevalent in the current empirical work on TFP measurement. The Harrod-Rymes measures are also briefly discussed in Section 2. The problems relating to the valuation of outputs and intermediate inputs are studied in Section 3, and those relating to the valuation of primary inputs in Section 4.

2. The Framework for Productivity Accounting

The derivation of TFP or MFP measures can, following Jorgenson and Griliches (1967) start from the following accounting identity:

$$\mathbf{q}'\mathbf{z} = \mathbf{p}'\mathbf{v} \tag{1}$$

where **q** is the price vector of outputs
z is the vector of output quantities
p is the price vector of inputs and
v is the vector of input quantities

The rate of growth of the total factor productivity t is defined as the difference of the growth rates of outputs and inputs:

$$t = \sum_i \alpha_i d\log z_i - \sum_j \beta_j d\log v_j = \sum_j \beta_j d\log q_i - \sum_i \alpha_i d\log p_i, \tag{2}$$

where α_i is the share of the i th output in total revenue, β_j the share of the j th input in total cost and $d\log y$ is the logarithmic time derivative of the variable y. This measure can be given an economic interpretation as the shift of the production function when a production function with constant returns to scale is assumed and all the relevant assumptions concerning markets and producer behavior are made.

On the other hand the representation of the accounting framework for productivity measurement can also start, following JGF (1987), by writing the production function of the j th industry in the form

$$X^j = F(M_1, M_2, \ldots M_N, K_1, K_2, \ldots K_M, L_1, L_2, \ldots L_R, T), \tag{3}$$

where the type of inputs is now specified either as intermediate inputs (M), capital inputs (K) or labor inputs (L). X^j is the output final to the industry, i.e. its gross

output less the output used by the industry itself as intermediate inputs.[1] Assuming producer equilibrium and constant returns to scale, the value of output is equal to the value of inputs:

$$q^j X^j = \sum_i p^{ij} M^{ij} + \sum_k p^k K^{kj} + \sum_l p^l L^{lj}, \quad i \neq j. \tag{4}$$

Provided that all the relevant conditions are met, the industry level rate of productivity growth is obtained by applying the formula in equation (2) to equation (4):

$$t_j = d\log X^j - (q^j X^j)^{-1} \left[\sum_i p^{ij} M^{ij} d\log M^{ij} + \sum_k p^k K^{kj} d\log K^{kj} + \sum_l p^l L^{lj} d\log L^{lj} \right]. \tag{5}$$

The output X^j final to an industry can be divided to deliveries X^{ij} to other industries i and to deliveries to final uses Y^j. Summing over the industries gives:

$$\sum_j q^j X^j = \sum_j \sum_i q^j X^{ij} + \sum_j q^j Y^j, \quad i \neq j, \tag{6}$$

where $\sum_j q^j Y^j$ is the value of the output final to the entire economy.

Assuming a closed economy all the intermediate inputs of an industry come from the rest of the industries. Each delivery from industry j to industry i is also an intermediate input to industry i. If the prices received by the producers of intermediate deliveries are equal to those paid by the users of these deliveries, i.e. if $q^j = p^{ji}$ for all j and i, then:

$$\sum_j \sum_i q^j X^{ij} + \sum_i \sum_j p^{ji} M^{ji}. \tag{7}$$

Summing over industries in equation (4) and deducting $\sum_j \sum_i q^j X^{ij}$ from both sides gives, when different categories of labor and capital inputs are suppressed, in view of equation (6) and (7):

$$\sum_j q^j Y^j = \sum_j p_k^j K^j + \sum_j p_L^j L^j. \tag{8}$$

Thus the value of final output of the economy as a whole, provided that the producers of intermediate deliveries receive the same prices as the users pay, is equal to its total value added. If there are imported inputs they have to be included in the primary inputs.

Applying the formula of equation (2) to equation (8) gives the measure of economy-level total factor productivity growth:

[1]The industry-level productivity measures are often calculated from gross output. However, when the economy level measure is based on the output final to the economy, it is logical to have an industry-level measure based on output final to the industry.

$$T = \left(\sum_j q^j Y^j \right)^{-1} \left[\sum_j q^j Y^j d\log Y^j - \sum_j p_k^j K^j d\log K^j - \sum_j p_L^j L^j d\log L^j \right] \tag{9}$$

On the additional assumption that all the industries pay the same prices for their capital and labor inputs, the economy-level measure can be obtained from the industry-level measures in equation (5) using the aggregation methodology introduced by Domar (1961):

$$T = \sum_j \frac{q^j X^j}{\sum_j q^j Y^j} t^j, \tag{10}$$

In the Domar-aggregation the weight of the *j* th industry is equal to the ratio of the value of the output final to the industry (i.e. its gross output less the intermediate inputs from the industry to itself) to the value of the final output of the economy (for proof see e.g. Domar, 1961; Hulten, 1978; Peterson, 1979; Wolff, 1985; Aulin-Ahmavaara, 1999; OECD, 2001a).

Unlike Domar (1961), JGF (1987) allows the prices paid by the users of intermediate inputs to differ from those received by the producers of these inputs. Therefore Domar (1961) aggregation in its original form does not apply. The value added of an economy is not any more equal to the value of final deliveries from it. In this case the weight of an individual industry is the ratio of the value of its total output to the total value added of the economy and not to the value of final output of the economy. The JGF (1987) aggregation formula also includes a term to reflect the contribution of changes in the distribution of value added between different industries. Since variation in the prices of labor and capital inputs is also allowed, additional terms are needed to reflect the contribution of changes in the distribution of these inputs.

The traditional TFP measures have been criticized, especially by Rymes (1971, 1983) and Cas and Rymes (1991), for not taking into account the fact that technical change in the production of capital means that less foregone consumption is needed to sustain a given quantity of capital. This effect is taken into account in the Harrod-Rymes type of measures advanced by them. The economy level H-R measure can be solved (see e.g. Rymes, 1983) from the following equation:

$$H = d\log Y - \alpha d\log L - (\beta + \gamma)(d\log K - H), \tag{11}$$

where α is the share of labor, β the share of net return on capital and γ the share of depreciation in income. Thus in view of equation (9)

$$H = \frac{T}{(1 - \beta + \gamma)} \tag{12}$$

If the growth rate of capital input is equal to the growth rate of output, the H-R rate is equal to the rate of labor productivity growth as can, after simple manipulation, be seen from equation (11). In this case labor appears to be the only primary input. However, when the growth rates of output and capital are not equal, there is an additional term in the H-R measure. It represents the efficiency of "waiting," which is this case emerges instead of capital as the other primary

input besides labour. For a thorough discussion of the concept of waiting see Rymes (1983) and Cas and Rymes (1991).

Industry-level Harrod-Rymes measures have been derived in somewhat different ways by Rymes (1983), Peterson (1979), Wolff (1985) and Cas and Rymes(1991).[2] According to Cas and Rymes (1991) the relationship between the traditional and H-R measures at industry level is:

$$\mathbf{h} = [\mathbf{I} - \mathbf{A}' - (\mathbf{E}' + \mathbf{D}')]^{-1}\mathbf{t}, \tag{13}$$[3]

where **h** is the vector of the H-R measures and **t** the vector of traditional measures, **A** is the matrix of input-output cost shares, **E** is the matrix of net returns to capital industry shares in gross output and **D** is the matrix of capital consumption allowances that industry shares in gross output. In the interpretation of the Harrod measures by Peterson (1979) and of the Peterson-Harrod measure by Wolff (1985) the matrix (**E′** + **D′**) would represent the gross investment requirements. There are diverging views on the correct aggregation of the industry-level Harrod-type measures.[4]

Accordingly there are in the derivation of the industry-level H-R measures as well as in their aggregation still issues that require clarification. Therefore, and also because of the space limitation, this paper concentrates mainly on the traditional measures. As Hulten (1992) notes, Hicksian and Harrodian concepts of technical change are complements, not competitors. But, as Hulten (1996) also notes, taking into account the productivity gains in the production of capital is not necessary for a reasonable accounting system nor is it consistent with the "year by year" view of standard theory. Nevertheless the H-R type measures of course are an important part of the analysis of economic growth and accordingly the open issues relating to them should be settled as soon as possible.

[2]The treatment of the rate of change of the depreciation rate in the derivation of their industry level measure is however unclear. In the traditional measure based on price changes given in their equation (1-27) there is no term representing this rate of change, while in their equation on page 32, where this measure is derived, there is. The measure based on quantity changes derived on page 30 does not include the rate of change of depreciation rate, while the one in equation (1-27) does. According to the authors these two measures are however identical the difference being caused by the assumption of a constant depreciation rate introduced on page 30. Thus it should be possible to equate the measure based on quantities in equation (1-27) with the one based on prices on page 32. But this would lead to a "fundamental dynamic identity," which would not, unlike the one given in their equation (1-26) include the rate of change of the depreciation rate weighted by the share depreciation.

[3]In the theoretical part of Cas and Rymes the matrices are not transposed, but in the empirical part (e.g. p. 120) they are correctly transposed.

[4]According to the theoretical part of Cas and Rymes (1991) the weights are each industry's contribution to net final output (p. 43, no proof). The empirical part (pp. 218–21) claims to prove that the weights are the gross final demand weights (equation (7-7)). Neither of these gives the economy level measure in equations (11) and (12) as a result. Equations (10), (12) and (13) give $H = \frac{T}{1-\beta+\gamma} = \frac{1}{1-\beta+\gamma} Y^{-1}(\mathbf{X}'(\mathbf{I} - \mathbf{A}' - (\mathbf{E}' + \mathbf{D}')\mathbf{h} = \frac{1}{Y-(\beta+\gamma)Y} \sum_i \left(Y_i - \sum_j E_{ij}X_j - \sum_j D_{ij}X_j\right)h_i$, where the prices have been omitted for simplicity. Accordingly the correct weight for each industry is the ratio of its contribution to net final output minus its contribution to net returns on capital to the total labor compensation of the economy. From Wolff (1985) one can conclude that net final demand weights would be the correct ones in case capital stock consumed would consist solely of depreciation. In case it would include also the net increase in capital stock, which is the Wolff (1985) interpretation of Peterson's (1979) interpretation of the "Harrodian "measures based on Rymes (1971), the final output should obviously also be net of inputs needed for net increase in capital.

3. Value of Output and Intermediate Inputs

3.1. *Net Taxes on Products in Symmetric Input-Output Tables*

An ideal situation for productivity analysis would be the one in which each producer is engaged in a single activity with a homogenous product. Actually this is something that the methodology of productivity measurement often seems to assume (see e.g. equations (3) and (4) above). Units of this kind that do not exist in the real world are in the SNA93 called "units of homogeneous production." They can be grouped into industries or products with only one type of output. They are the basis of the symmetric input-output tables, in which joint production in fact is by definition ruled out.

In the symmetric input-output table, outputs and intermediate inputs as well as intermediate and other uses have the same basis of valuation. The recommended one in the SNA93 is the basic price. Basic price is equal to the price received for a product by its producer. It does not include taxes on products, i.e. taxes paid on the basis of the quantity produced or sold. It does include similar subsidies. Taxes on products include value added type taxes, taxes and duties on imports and other taxes on products. Value added type taxes are in the SNA described as deductible, since producers can deduct taxes invoiced on their own purchasers for intermediate consumption or fixed capital formation from the amount of the tax they invoice to their customers. However value-added type taxes are not paid on output for own final use (e.g. services of owner occupied dwellings) or on other non-market output, simply because they are not sold. Neither are they normally paid on financial intermediation and insurance services. In these cases producers can of course not deduct the value added taxes they have paid on their intermediate inputs. Besides, value added tax paid on some categories of intermediate inputs (e.g. entertainment cost) may not be deductible to any producer. Import duties and other taxes on products (e.g. general sales tax; excise duties levied on specific kinds of goods, typically alcoholic beverages, tobacco and fuels; taxes on specific services, such as communication, transportation, insurance, advertising, restaurants; taxes on financial and capital transactions and profits of fiscal monopolies) are normally also paid on the intermediate uses of the products concerned. Therefore there are always taxes and subsidies on products relating to intermediate inputs.

In Table 1 it is assumed for simplicity that there are no imports. Since inputs and outputs are valued at the same prices, the value of intermediate inputs is at the level of the national economy equal to the value of intermediate consumption. The final uses consist of separate products valued at basic prices. However, equation (8) is not valid since from Table 1:

(14) Final uses at basic prices = nondeductible part of value added type taxes on intermediate inputs + other net (of similar subsidies) taxes on products used as intermediate inputs + gross value added at basic prices

Accordingly:

> The value of primary inputs should, besides gross value added at basic prices, include all the net taxes on products used as intermediate inputs. Final uses consist of separate products valued at specified prices and Domar aggregation in its original form can be applied.

TABLE 1

VALUES OF OUTPUT AND USES IN SYMMETRIC INPUT-OUTPUT TABLE AT BASIC PRICES, TOTAL ECONOMY

Value of Output	Value of Uses
Intermediate inputs at basic prices	Intermediate consumption at basic prices
+ non-deductible part of value added type taxes on intermediate inputs	+ final uses at basic prices
+ other net (of similar subsidies) taxes on products used as intermediate inputs	
= intermediate inputs at purchasers' prices	
+ gross value added at basic prices	
= value of total output at basic prices	= value of total output at basic prices

TABLE 2

VALUES OF OUTPUT AND USES IN SYMMETRIC INPUT-OUTPUT TABLE AT PRODUCERS' PRICES, TOTAL ECONOMY

Value of Output	Value of Uses
Intermediate inputs at basic prices	
+ other (than VAT) net taxes on products used as intermediate inputs	
= intermediate inputs at producers' prices	Intermediate consumption at producers' prices
+ non-deductible part of value added type taxes on intermediate inputs	+ final uses at producers' prices
= intermediate inputs at purchasers' prices	
+ gross value added at basic prices	
= value of total output at basic prices	
+ other than value added type net taxes on products in domestic output	
= value of total output at producers' prices	= value of total output at producers' prices

In case intermediate inputs are valued at basic prices the net taxes on products used as intermediate inputs has to be included in the value of primary inputs in the H-R measures as well, as they correctly are in the empirical part of Cas and Rymes (1991). This is because primary inputs and intermediate inputs are the only alternatives. Together they have to cover the value of output.

Another possibility is to use producers' prices in the input-output table instead of basic prices, although the SNA93 recommends basic prices. Producers' prices include all the net (of subsidies) taxes on products other than the value added type taxes.

Again it is assumed that there are no imports. Intermediate inputs and outputs are valued at common prices. The final uses consist of separate products valued at producers' prices. But, again equation (8) is not valid, since from Table 2:

(15) Final uses at producers' prices = nondeductible part of value added type taxes on intermediate inputs + gross value added at basic prices + other than value added type net taxes on products in domestic output.

Accordingly:

> The value of primary inputs should, besides gross value added at basic prices, include nondeductible part of value added type taxes on intermediate inputs

and other than value added type net taxes on products in domestic output. Final uses consist of separate products valued at specified prices and Domar aggregation can be applied in its original form.

The fact that taxes on products should partly be covered by the value of primary inputs is not a problem caused by the SNA93. It is necessary for the final output to consist of separate products valued at specified prices, as is required, for example, by the original form of Domar aggregation. Symmetric input-output tables are perfectly in accordance with this requirement. Again net taxes on products that are not covered by intermediate inputs has to be covered by the primary inputs also in H-R measures, because these are the only possible alternatives. Again, this problem is not caused by the properties of the SNA, which truthfully reflects the existing economic systems.

The valuation of symmetric input-output tables at purchasers' prices is not recommended by the SNA93. One reason might be that it is not possible to allocate to industries the VAT paid on their output. If valuation were based on purchasers' prices then the primary inputs should, as can be easily concluded, for example, from Table 2, both in the case of traditional and in the case of H-R measures, include the all net taxes (VAT included) on products on output and none on intermediate inputs. This again is necessary simply for the values of intermediate and primary inputs to add up to the value of output.

3.2. *Net Taxes on Products in Supply and Use Tables*

In reality producers are of course not homogeneous units of production, but institutional units, called in the SNA93 enterprises in their capacity as producers, or parts of such units called establishments. Establishments with the same principal activity are grouped into industries. Enterprises can also be grouped into industries. Industries formed of establishments are however more homogeneous than those formed of enterprises. For the detailed analysis of production the SNA93 therefore recommends the industries to be defined as groups of establishments engaged in the same kind of productive activities.

Productive activities of industries are analyzed in the product by industry supply and use tables. In supply and use tables joint production is possible. Outputs are valued at basic prices, and uses originally at purchasers' prices. This makes the supply and use table framework similar to the JGF (1987) framework. In JGF (1987, p. 160) output is said to be valued at producers' prices, but these prices are actually the same as basic prices in the SNA93 framework. The uses are said to be valued at purchasers' prices but are, again using the terminology of SNA93, valued at purchasers' prices minus trade and transport margins. The latter difference of course matters only in the case of individual intermediate inputs and does not affect the total value of intermediate inputs of an industry.

In Table 3 it is again assumed that there are no imports. The output used as intermediate inputs is valued at basic prices and intermediate consumption at purchasers' prices. The difference covers exactly the value added at basic prices. However from Table 3:

(16) Gross value added at basic prices = final uses at purchasers' prices – all net taxes on products.

TABLE 3

VALUES OF OUTPUTS AND USES IN SUPPLY AND USE TABLES, TOTAL ECONOMY

Value of Output	Value of Uses
Intermediate inputs at basic prices	
+ all net taxes on products used as intermediate inputs	
= intermediate inputs at purchasers' prices	Intermediate consumption at purchasers' prices
+ gross value added at basic prices	+ final uses at purchasers' prices
	= value of total output at purchasers' prices
	– all net taxes on products
= value of total output at basic prices	= value of total output at basic prices

Since the value of final uses at purchasers' prices is equal to the value of final uses at basic prices plus net taxes on products in final uses, this can also be expressed as follows:

(17) Gross value added at basic prices = final uses at basic prices – all net taxes on products used as intermediate inputs.

Subtracting net taxes on products used as intermediate inputs from final uses at basic prices, as suggested by the OECD (2001a) productivity manual, does not lead to a valuation of final uses based on any specified price concept. The OECD manual refers to the similar treatment of taxes on products for the separation of (final) output by Ezaki and Jorgenson (1995). However, as can be seen from their equation (2.3.3), Ezaki and Jorgenson (1995) assume that there are no taxes on products used as intermediate inputs. Another problem in this treatment, if applied to VAT type taxes, is the assumption that tax rates on consumption and investment goods are equal (Ezaki and Jorgenson, 1995, equation 2.3.7). Market producers are in most cases entitled to deduct the value added type tax invoiced on their purchases from the taxes they invoice to their customers and therefore mostly do not pay VAT on their purchases of investment goods. Accordingly:

> In the case of supply and use tables the difference between the output valued at basic prices and the intermediate inputs at purchasers' prices covers exactly the value added at basic prices. However, the aggregate value added at basic prices cannot be allocated to separate products or categories of final output valued at specified prices and therefore the Domar aggregation in its original form cannot be applied. But the JGF (1987) type of aggregation based on the aggregate value added is of course possible.

Here again the problem relating to the separation of final output is not caused by the treatment of taxes on products in the SNA93 supply and use tables, but follows from the fact that in productivity measurement the valuations of intermediate inputs and outputs are based on different price concepts. The SNA93 supply and use tables are perfectly in accordance with this requirement.[5] If differ-

[5]Diewert (1996) suggests that "The identification and appropriate treatment of taxes is a topic that deserves high priority in the next revision of the system of national accounts." However the SNA93 supporting table of trade and transport margins and taxes and subsidies on products (table 15.2) gives very detailed information about the margins. The question is in which way this information should be used in productivity measurement.

ent prices were used in H-R measures then it is obvious that the difference between output and intermediate inputs does not represent the value of final output based on any price concept, unless of course there are no taxes on products related to intermediate inputs. But in the existing economies this is generally not true. Since value added in this case cannot be allocated to the categories of final uses, it is not possible to identify the value of the final output used for gross capital formation (fixed capital and inventories), as at least some interpretations of the H-R-measures would require. Also in the case of traditional measures the feedback to gross capital formation is sometimes sought after. This is also impossible in the case of non-identical prices.

3.3. *Non-market Producers and Non-market Output*

The output produced by establishments that is sold or intended to be sold at economically significant prices on the market is in the SNA93 called market output. Besides, establishments can produce output for the final use of the owners of the enterprise of which they are a part (output for own final use) or output that is supplied free or at economically insignificant prices (other non-market output). The neoclassical theory of production underlying productivity measurement consists of a production function with constant returns to scale with the necessary conditions for producer equilibrium in a perfectly competitive market (see e.g. Jorgenson and Griliches, 1967). Thus it obviously does not concern non-market activities, where no prices exist or where existing prices are not economically significant. This is one reason for separating market and non-market output in productivity analysis. The OECD (2001a) productivity manual recommends special methods for dealing with non-market activities. Also the BLS MFP measures concern only the "private business sector" (Dean and Harper, 2001).

An additional reason for treating market and non-market output separately is the difference in the basis of valuation in the SNA93. Market output and output for own final use are valued at basic prices, but the other non-market output is valued at production cost. These include the cost of intermediate inputs and labor as well as consumption of fixed capital. No interest cost or net return on capital is included. For example, Diewert (1996) considers this treatment of interest cost incorrect, and Christensen and Jorgenson (1973) impute net rent on institutional real estate.

In the symmetric input-output tables of the SNA93 neither market output and non-market output on the one hand nor market producers and non-market producers on the other are separated from each other. In the supply and use table environment market producers and non-market producers are treated in principle separately. The only problem is the—usually relatively small—amount of market output produced by non-market producers that has to be dealt with in one way or other.

4. The Value of Primary Inputs

4.1. *Other Taxes and Subsidies on Production*

When the value of intermediate inputs is subtracted from the total value of output the residual in any case includes value added at basic prices. Value added

at basic prices consists in the SNA93 of the compensation of employees, of other taxes on production net of respective subsidies,[6] and of operating surplus and mixed income. Other taxes on production as well as similar subsidies can at least in principle be allocated to those relating to labor and to those relating to capital. This is what is done by JGF (1987), for example.

4.2. *Labor Compensation*

Obviously the compensation of employees in the SNA93 is part of the labor compensation in productivity analysis. Payroll taxes are specifically not included in compensation of employees in the SNA93. When the SNA93's other taxes on production are in the productivity analysis allocated to labor and capital inputs, payroll taxes should be included in the value of labor input (see e.g. JGF, 1987).

Part of the mixed income should also be allocated to compensate the labor input of self-employed. The SNA93 suggests (paragraph 10.102) the imputed compensation per hour worked by a self-employed person to be estimated on the basis of the wage of an employee with similar background and job characteristics in the same industry. However social contributions paid by the self-employed for themselves should be taken into account. Since the value of these contributions is not likely to be available by industry, it can, for example, be assumed, as suggested by the OECD productivity manual (2001a) that the average compensation of labor to the self-employed is equal to average compensation of labor to the employees. For this the labor input can also be differentiated by skill and other relevant characteristics. On the other hand, JGF (1987), for example, prefers the estimation of the compensation of self-employed labor as the difference of non-corporate income and return on non-corporate capital. The after tax rates of return on capital are assumed to be equal for non-corporate and corporate business.

4.3. *Imputed Rentals of Fixed Capital*

After labor compensation and net taxes on production are deducted from the value added at basic price, the residual in the SNA93 framework is the operating surplus added by that part of mixed income that is comparable to operating surplus. Operating surplus is not treated as compensation to capital, although, for example, paragraphs 2.113 and 2.115 give the impression that the part of value added that is not distributed to labor or government or the rest of the world belongs to capital. But this is not elaborated further in the publication. However, rentals of fixed capital are discussed in the context of the production account when consumption of fixed capital is defined.

A characteristic feature of fixed capital, according to the SNA93, is the fact that it is repeatedly and continuously used in the production process. In productivity measurement within the neoclassical framework it is generally agreed that the input of fixed capital should preferably be represented by the services of productive capital stock (see e.g. OECD 2001a, 2001b). Likewise the value of these services should be measured by the actual or estimated rental price or user cost of

[6]These include taxes and subsidies on production, excluding those on products. Taxes and subsidies on products are those associated with the quantities produced or transacted.

fixed capital. The SNA93 does not mention productive capital stock, or its services, but it does mention the profiles of efficiency decline, from which the concept of productive capital stock should logically follow.

It is also generally accepted in productivity analysis (see e.g. OECD 2001a, OECD 2001b) that the rental price of a fixed asset can be estimated, or imputed, by the Hall-Jorgenson (1967) user cost formula:

$$\mu_t = r_t q_{t-1} + d_t q_t - q_t - q_{t-1}, \quad (18)$$

where q_t is the price of the asset concerned. The term $r_t q_t$ represents the return on capital, the term $d_t q_t$ depreciation of capital, and the last term $q_t - q_{t-1}$ is the asset-specific revaluation term. According to the SNA93 (paragraph 6.181) the rental of fixed asset should cover the consumption of fixed capital, interest cost on the value of the asset and any other cost incurred by the owner. Whether this would be equal to the total value of the Hall-Jorgenson user cost depends of course on the definition of the components. The other costs incurred by the owner are not specified in the SNA.

Consumption of fixed capital is in the SNA93 (6.179) defined as the normal decline of its current value as a result of physical deterioration, normal obsolescence and normal accidental damage. This is also called time series depreciation, while the difference in the value of assets of different ages at the same point of time is called cross section depreciation (e.g. Hill, 1999; Diewert, 2001). According to Hill (1999) consumption of fixed capital (i.e. time series depreciation) includes, in addition to cross section depreciation, foreseen asset revaluation due to obsolescence or other factors (not specified). On the other hand consumption of fixed capital is according to the SNA93 (paragraph 6.193) also "proportional to the reduction in the present value of remaining rentals, as explained earlier." What is explained earlier is, among other things, that "The amounts of rentals which users are prepared to pay will be proportional to the relative efficiencies of the assets" (paragraph 6.192). In which way obsolescence that is assumed to contribute to the consumption of fixed capital is reflected in these relative efficiencies is not explained.

The concept of depreciation used in productivity analysis is cross-section depreciation (see e.g. JGF, 1987; Hulten, 1996; OECD, 2001a). Changes in asset price caused by obsolescence are, according to Fraumeni (1997), for example, included in the revaluation term. However, in the productive capital stock, capital goods are supposed to be measured in standard efficiency units, i.e. in units with equal marginal productivity. For this the fact that assets in a new vintage can already originally be more efficient than earlier ones has to be taken into account. Otherwise the services of different vintages would not be perfectly substitutable. Holding the quality of an asset constant, there is, according to Jorgenson (1999), no role for obsolescence. This implies the use of constant quality, or hedonic, price indices.

Accordingly:

[7]In this form the user cost formula can be found, e.g. in Jorgenson and Stiroh (2000). Diewert (2001) has shown that essentially the same user cost formula was obtained by Walras in 1874.

> The definition of the rental of fixed assets in the SNA93 is not detailed enough to make it possible to decide whether the total value of the rental of a fixed asset according to the SNA93 would be equal to its Hall-Jorgenson user cost. The exact relationship between depreciation, efficiency decline and obsolescence seems not to be given in the SNA93.

In the H-R measures capital is not a primary input as explained in Section 2 of this paper. However the values of depreciation and net return on capital are also needed for these measures. In Cas and Rymes (1991) depreciation is defined as "a decline in the price of a capital good as it ages." This seems to refer to cross-section concept of depreciation. On the other hand no separate revaluation term is included. In their empirical part SNA capital consumption allowances are used to represent depreciation.

The user cost formula of neoclassical measures as well as the H-R measure both require estimates of the net rates of return on capital. According to the SNA93 (paragraph 6.181) interest cost included in the rental price of an asset may consist "either of actual interest paid on borrowed funds or the loss of interest incurred as a result of investing own funds in the purchase of a fixed asset instead of a financial asset." The former has to be reduced by the margins that represent the implicit charges for the services of the financial intermediaries (SNA93, 7.108), which should be treated as intermediate inputs. The interest receivable by the depositors must be similarly increased. To balance this increase the financial intermediaton services are recorded as intermediate inputs. In case a firm uses its own funds to finance an investment, it actually only loses the non-adjusted interest. This loss of interest should obviously not, in the calculation of user cost, be adjusted to cover the cost of the services of financial intermediaries, because none are needed.

The OECD (2001b) capital manual suggests, as one possibility, use of the average of the interest rate that should be paid on borrowed funds and the interest rate that could be earned by investing in financial assets. The procedure suggested by the manual can be interpreted to mean that the services of financial intermediaries are deducted from the interest on the borrowed funds. In the case of own funds, however, it would mean that the loss of interest would include, in addition to the possible interest on financial assets, compensation for the cost of the services of financial intermediaries, which do not occur in this case. Accordingly:

> The procedure suggested by the OECD capital manual for the calculation of the rate of return on capital from actual interest rates seems to be in principle identical with the one suggested by the SNA93. Neither seems to give a conclusive answer to the question of the correct interest rate and the treatment of the services of financial intermediaries that is in harmony with that choice.[8]

An additional problem with the services of financial intermediaries is that firms may use them for financial operations that are not necessarily part of their productive activity.

[8]Keuning (1999) suggests the services of financial intermediaries to be treated as a primary input. However these services, quite obviously, are produced by utilizing labor and capital inputs as well as intermediate inputs.

4.4. *Estimating the Ex-post Rate of Return*

The other possibility is to calculate the rate of return ex-post (see e.g. JGF, 1987; Hulten, 1996; OECD, 2001b). For this, however, the total value of capital compensation for the group of producers, e.g. those forming an industry, is needed. Unlike compensation of employees, total value of compensation of capital is not defined in the SNA93.

Obviously the user cost of all the assets that are tied up in the production process should be covered. The capital account and the balance sheet of SNA93 give a list of possible assets of an enterprise. These include, in addition to produced fixed assets, inventories, valuables, non-produced non-financial assets and financial assets. All of these assets are not necessarily involved in the production process. Valuables are, according to the SNA93, not used primarily for production but as stores of value. Inventories, on the other hand, are likely to be part of the production process.

Non-produced tangible assets, i.e. land and non-cultivated forests and minerals, are also needed in the production process. Land and subsoil assets can also be rented. This means that the rents paid by producers should be treated either as separate primary inputs (c.f. Keuning, 1999) or as intermediate inputs. In the latter case services of land should also be produced. Renting land is, in the SNA93, not regarded as productive activity, although it might require at least some "administrative" work from the part of the owner. Intangible non-produced assets such as patents concerning production technology, transferable leases, and purchased goodwill should be treated in the same way as the tangible ones.

At least some of the financial assets are also needed in the production process. For example, in retail trade it is necessary to keep some cash and probably in any type of business activity it is necessary, for liquidity reasons, to keep some non-interest bearing deposits or other financial instruments that bear a lower than normal interest. This should also be compensated from the operating surplus.

Thus the operating surplus can in principle be broken down as follows:

(18) Gross operating surplus = user cost of produced fixed capital + user cost of inventories + user cost of land and other non-produced non-financial assets + cost of hiring non-produced assets + user cost of financial assets needed in the production process + residual.

The asset classes that are compensated are about the same as in JGF (1987). The exceptions are the cost of hiring non-produced assets and, of course, the residual. The problem is that the assets are owned by institutional units and not by establishments involved in the production process. The balance sheet is, in the SNA93, drawn only for institutional sectors and not for industries. However, since consumption of fixed capital appears in the production account, fixed capital has to be in the SNA93 allocated to establishments and industries as well. Rents on land are in the SNA 93 treated as property income. They are shown in the

allocation of primary income account, which is also drawn only for sectors, not for industries.[9]

Accordingly:

> If operating surplus is assumed to be equal to capital compensation, it is in principle possible to calculate the ex-post rate of return in the SNA93 environment. The problem is that assets, except for produced fixed capital and inventories, are not allocated to industries. Neither are rents on land distributed by industry in the SNA93

5. Conclusions

For the measurement of productivity change a full set of volume and price accounts is needed. For this it is necessary to have a complete set of values. The aim of this paper was to find the possible problems in the utilization of SNA93 accounts as a consistent set of data on values needed in productivity measurement mainly in the neoclassical growth accounting framework. Also the problems in the case of Harrod-Rymes type of measures were briefly discussed. Several problems were found. Some could be solved by revising the SNA93, while others are caused by what seems to be contradictory requirements of productivity accounting.

In the case of the values of outputs and intermediate inputs the main problems are connected with the taxes and subsidies on products. But the fact that the net taxes on products are, in the case of the symmetric input-output tables, partly left to be covered by the value of primary inputs, is not caused by the SNA93. It follows from the fact that outputs and intermediate inputs are valued at identical prices. Final uses consist in this case of separate products valued at specified prices and Domar aggregation in its original form is possible. In the case of the supply and use tables the difference between output valued at basic prices and intermediate inputs at purchasers' prices covers exactly the value added at basic price. Domar aggregation in its original form is not possible, but the aggregation based on value added is. However, the aggregate value added cannot be allocated to separate products or to categories of final output valued at specified prices. This naturally concerns the H-R measures as well, if based on non-identical prices. Since value added in this case cannot be allocated to the categories of final uses, it is not possible to identify the value of the final output used for gross capital formation (fixed capital and inventories), as at least some interpretations of the H-R measures would require. Also in the case of traditional measures the feedback to gross capital formation is impossible in the case of non-identical prices.

The neoclassical theory of production underlying productivity accounting actually concerns only market production. Also the valuation of non-market

[9]Keuning (1999) includes in the production balance sheet of enterprises, about the same assets as the left hand side of (18). However the assets tied up in the production process do not actually earn any return. Instead the interest paid for liabilities used to finance production is treated as production cost and the rest of the net operating surplus is treated as return on shares, other equity and net worth of the enterprise. But since financial arrangements normally concern enterprises, these assets can hardly be allocated to establishments for productivity analysis. Also the meaning of depreciation in the case of a fixed asset that is, as such, not assumed to earn any return is not quite obvious.

output differs in the SNA93 from that of market output. Therefore it is important to treat the market and non-market producers separately. In the supply and use table environment this is the case, but in symmetric input-output tables it is not.

In productivity accounting the other (than those on products) taxes on production as well as mixed income are allocated to labor and capital inputs. It would be helpful if the system of national accounts could give clear guidance on this.

Unlike labor input and compensation of employees, capital input and total value of compensation of different types of assets are not defined in the SNA93. The rentals of fixed capital are discussed in the context of the production account. The definition of rental of fixed assets in the SNA93 is not detailed enough to make it possible to decide whether the total value of rental of a fixed asset according to the SNA93 would be equal to its Hall-Jorgenson user cost. The treatment of obsolescence is problematic. The exact relationship between depreciation, efficiency decline and obsolescence is not explicitly given in the SNA93.

The procedure suggested by the OECD capital manual for the calculation of the rate of return on capital from actual interest rates seems to be in principle identical with the one suggested by the SNA93. Neither seems to give a conclusive answer to the question of the correct interest rate and the treatment of the services of financial intermediaries that is in harmony with that choice.

If operating surplus is in the SNA93 assumed to be equal to capital compensation, then it is in principle possible to calculate the ex-post rate of return in the SNA93 environment. However it is not possible to calculate the ex-post rate of return for an industry, because all the assets used in the production process are not allocated to industries. Neither are rents on land distributed by industry in the SNA93. This is basically caused by the fact that the assets are owned by institutional units and not by establishments, which are the preferred basis for the classification by industry.

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