Chapter 18: Measuring prices, volumes and productivity

(revised title and revised content)
(OLD Chapter 15: Price and volume measures)

A. Introduction

18.1 Chapter ~~14~~ 15 describes how the goods and services account may be compiled and elaborated within a supply and use table. The changes in the values of flows of goods and services can be directly factored into two components, one reflecting changes in the prices of the goods and services concerned and the other the changes in their volumes. One major advantage of compiling price and volume measures within an accounting framework, such as that provided by the supply and use tables, is that a check is provided on the numerical consistency and reliability of the set of measures as a whole. This is particularly important when every flow of goods and services in the economy has to be covered, including non-market goods and services whose valuation is even more difficult in volume terms than at current prices.

18.2 Another advantage of compiling price and volume measures within an accounting framework is that implicit price or volume measures can be derived for certain important balancing items. In particular, gross value added can be measured in real terms by subtracting intermediate consumption in volume terms from output in volume terms, the so-called "double deflation" method. Double deflation may be used at the level of an individual enterprise, industry or sector. However, the primary objective of the SNA is not simply to provide guidelines on measures of changes in prices and volumes for the main aggregates of the SNA but to assemble a set of interdependent measures that make it possible to carry out systematic and detailed analyses of inflation and economic growth.

1. Index number theory

18.3 Section B gives an overview of the theory of index numbers as applied in the SNA. ~~New m~~Manuals have been published on the theory and practice of consumer price indices (CPIs) and on producer price indices (PPIs). These are *Consumer Price Index Manual: ~~Theory and Practice~~Concepts and Methods, (*International Monetary Fund, International Labour Organization, ~~International Monetary Fund~~Statistical Office of the European Union (Eurostat), United Nations Economic Commission for Europe, Organisation for Economic and Co-operation and Development, ~~Eurostat, United Nations Economic Commission for Europe~~ and the World Bank (~~2004~~2020)) and *Producer Price Index Manual: Theory and Practice, (*International Labour Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, Economic Commission for Europe and the World Bank (2004).) A further manual on export and import price indices (XMPIs), *Export and Import Price Index Manual: Theory and Practice* (International Labour Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations Economic Commission for Europe and World Bank (2009)). In particular chapter 2 of the CPI manual, chapter 14 of the ~~CPI and~~ PPI manual~~s~~ and chapter 15 of the XMPI manual outline how such indices fit into the framework of the SNA.

Commented [ED1]: References to several manuals or handbooks have been updated to reflect new editions published since 2008.

18.4 The first topic in section B concerns the choice of an appropriate methodology for compiling inter-temporal price and volume measures for flows of goods and services in a national accounting context. Section B also deals with the consequences of price variation due to price discrimination; that is, how to treat goods or services that are sold to different purchasers on the same market in the same period at different prices. Such differences need to be clearly distinguished from price differences attributable to differences in qualities. This section also discusses the treatment of changes in quality over time, including the appearance of new products and the disappearance of old products.

2. Inter-temporal price and volume series

18.5 Section C shows how the considerations in section B can be applied to the SNA and time series of volumes and prices be derived. It discusses not only the elements of the goods and services account but also how stocks of non-financial assets can be decomposed into price and volume elements. ~~Further, the section addresses the question of expressing key aggregates of the SNA that do not themselves have price and volume components in real terms, allowing an analysis of the impact of terms of trade on national income, for instance.~~

18.6 Like section B, section C does not aim to be exhaustive in its coverage but draws on, and refers to, other manuals, specifically the *Handbook on Prices and Volume Measures in National Accounts* (Eurostat, ~~2001~~2016) and chapter IX of *Quarterly National Accounts Manual* (International Monetary Fund (IMF), 2017).

3. Real income

18.7 Section D addresses the question of expressing key aggregates of the SNA that do not themselves have price and volume components in real terms, allowing an analysis of the impact of terms of trade on national income, for instance.

4. Volume measures for particular products

18.8 The methods discussed in Section C of this chapter can be used to appropriate derive volume and price measures for most products. For a few products that have unusual characteristics, this general guidance may not be sufficient, and Section E provides more specific guidance for those cases. The specific guidance in this section draws from handbooks such as Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition and other handbooks that are cited in the section.

5. Productivity

18.9 Section F describes measures of productivity, which measure changes in the volume of output relative to changes in the volume of inputs. These measures are ratios in which the numerator is a volume measure of output or value added and the denominator is a volume measure of one or more inputs, especially of labour, capital or the combined contributions of labour and capital. This section draws on the handbooks, *Measuring Capital* (Organisation for Economic Co-operation and Development (OECD), 2009) and *Measuring Productivity* (OECD, 2001).

~~3.~~6. International price comparisons

~~18.7~~18.10 Although most price and volume index numbers were developed to measure changes in prices and volumes over time, they can also be adapted to compare levels of prices and volumes between different regions or countries in the same period of time. Such comparisons are needed in order to be able to compare standards of living, levels of economic development or levels of productivity in different countries.

~~18.8~~18.11 These topics are addressed in section ~~D~~G, first in theoretical terms and then in terms of the implications for national accountants. Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program—ICP (World Bank, 2013) describes the methodology underlying the International Comparison Program (ICP).

~~4.~~7. Further information

~~18.9~~18.12 This chapter aims to do no more than introduce the most important concepts and considerations of the application of index number theory to the derivations of volume series within the SNA. Further information should be sought from the other manuals cited.

B. An overview of index number theory

1. Quantities, prices and values

~~18.10~~18.13 For each individual type of good or service it is necessary to specify an appropriate quantity unit in which that good or service can be measured. Goods or services may be supplied in units that are either discrete or continuously variable. Automobiles, aircraft, microcomputers, haircuts and appendectomies are examples of goods or services provided in discrete or integral units. The quantities of such goods and services are obtained simply by counting the number of units. Oil, electricity, sugar and transportation are examples of goods or services provided in units that vary continuously in respect of characteristics such as weight, volume, power, duration and distance. The choice of physical unit, and its price in relation to the unit selected, is therefore a matter of convenience. For example, the price quoted per tonne is one thousand times greater than one quoted per kilo. As long as the price is expressed in a manner consistent with the unit of volume, the value (v) at the level of a single, homogeneous good or service is equal to the price per unit of quantity (p) multiplied by the number of quantity units (q), that is: $v = p \text{ x } q$.

Additivity of quantities, prices and values

~~18.11~~18.14 Certain important properties in relation to the additivity of quantities, prices and values may be briefly noted:

a. Quantities are additive only for a single homogeneous product. For example, it is not economically meaningful to add 10 tonnes of coal to 20 tonnes of sugar. Less obviously, the addition of 10 automobiles of one type to 20 automobiles of another type would not be economically meaningful either if they differ in quality.

b. ***The price of a good or service is defined as the value of one unit of that good or service***. It varies directly with the size of the unit of quantity selected and in many cases can be made to vary arbitrarily by changing the unit of quantity, for example, by choosing to measure in tonnes instead of in kilograms. Prices, like quantities, are not additive across different goods or services. An average of the prices of different goods or services has no economic significance and cannot be used to measure price changes over time.

c. Values are expressed in terms of a common unit of currency and are additive across different products. Values are invariant to the choice of quantity unit.

~~18.12~~18.15 In a market system, the relative prices of different goods and services should reflect both their relative costs of production and their relative utilities to purchasers, whether the latter intend to use them for production or consumption. Relative costs and relative utilities influence the rates at which sellers and buyers are prepared to exchange goods and services on markets. An aggregation of the values of different goods and services necessarily reflects the choices of which goods and services have been produced and consumed at the currently prevailing prices.

Volume, quantity, price and unit value indices

~~18.13~~18.16 ***A volume index is an average of the proportionate changes in the quantities of a specified set of goods or services between two periods of time***. The quantities compared over time must be those for homogeneous items and the resulting quantity changes for different goods and services must be weighted by their economic importance, as measured by their relative values in one or other, or both, periods. For this reason volume is a more correct and appropriate term than quantity in order to emphasize that quantities must be adjusted to reflect changes in quality.

~~18.14~~18.17 Unfortunately, it may sometimes happen, especially in the field of foreign trade statistics based on customs documentation, that the data from which price and volume indices have to be calculated are not sufficiently detailed or are otherwise inadequate for the purpose. For example, the basic information available may be limited to the total number of units of some group of products imported or exported, or their total weight, for example, the total number of pairs of shoes, or total weight of equipment of a certain type. Indices built up from information of this kind are not volume indices when the numbers, or weights, cover different items selling at different prices. They are sometimes described as “quantity indices” for this reason. The “price” indices associated with such indices are usually described as average or “unit value” indices. Unit value indices measure the change in the average value of units that are not necessarily homogeneous and may be affected by changes in the mix of items as well as by changes in their prices. Unit value indices cannot therefore be expected to provide good measures of average price changes over time for groups of non-homogeneous items.

2. Inter-temporal index numbers of prices and volumes

~~18.15~~18.18 The index numbers of interest within the SNA are designed to decompose changes in value aggregates into their overall change in price and volume components. A price index can be written and calculated as a weighted average of the proportionate changes in the prices of a specified set of goods and services between two periods of time, say a reference period 0 and current period *t*. Similarly, a volume index can be written and calculated as a weighted average of the proportionate changes in the volumes of a specified set of goods and services between two periods of time, say a reference period 0 and current period *t*. There are many index number formulae differing from each other mainly in the weights which they attach to the individual price or quantity relatives and the particular form of average used, whether it is arithmetic, geometric, harmonic, etc. These alternative formulae, their properties and relative merits, are outlined in detail in the CPI and PPI manuals.

Laspeyres and Paasche indices

~~18.16~~18.19 The two most commonly used index formulae are the Laspeyres and Paasche indices. The Laspeyres price index (*Lp*) is defined as a weighted arithmetic average of the price relatives using the value shares of the reference period 0 as weights:

$$L_p = \sum_{i=1}^{n} \left(\frac{p_i^t}{p_i^0}\right) S_i^0 = \frac{\sum_{i=1}^{n} \left(\frac{p_i^t}{p_i^0}\right) p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} \equiv \frac{\sum_{i=1}^{n} p_i^t q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} \qquad (1)$$

That is, where $p^0_{i,}$ q_i^0 and $v_i^0 = p_i^0 \, x \, q_i^0$ are the prices, quantities and values in period 0 of $i = 1, \dots, n$ products and $s_i^0 = v_1^0 / \sum_{i=1}^{n} v_{i,}^0$ the value shares in period 0. Similar expressions with superscripts *t* refer to period *t*.

~~18.17~~18.20 Note from (1) that the Laspeyres price index can be defined as the change in value of a basket of products whose composition is kept fixed as it was in the reference period 0. The Laspeyres volume index (LQ) can be similarly defined as the change in the value of a basket whose composition every period is updated but the prices of the reference period 0 are applied to the new quantities (or volumes), that is:

15.17

$$L_{Q=} \sum_{i=0}^{n} \left(\frac{q_i^t}{q_i^0}\right) S_i^0 \equiv \frac{\sum_{i=1}^{n} p_i^0 q_i^t}{\sum_{i=1}^{n} p_i^0 q_i^0} \qquad (2)$$

~~18.18~~18.21 Paasche indices also exist in both price and volume forms. The Paasche index differs from the Laspeyres index in two respects. It uses a harmonic mean instead of an arithmetic average and the fixed period volumes or prices are those of the current period t. The Paasche price index is given by:

$$P_p = \left[\sum_{i=1}^{n} \left(\frac{p_i^t}{p_i^0}\right)^{-1} S_i^t\right]^{-1} \equiv \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^0 q_i^t} \qquad (3)$$

and a Paasche volume index, with fixed current period weights or prices, by:

$$P_Q = \left[\sum_{i=1}^{n} \left(\frac{q_i^t}{q_i^o}\right)^{-1} S_i^t\right]^{-1} \equiv \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^t q_i^o} \qquad (4)$$

Deflation and volume series using Laspeyres and Paasche formulae

~~18.19~~18.22 The index of the change in monetary values between two periods, $I_v = \sum_{i=1}^{n} v_i^t / \sum_{i=1}^{n} v_i^{t-1}$, reflects the combined effects of both price and quantity changes. When Laspeyres and Paasche indices are used, the value change will exactly decompose into a price index times a volume index only if the Laspeyres price index is matched with the Paasche volume index, that is: $L_P \times P_Q = I_V$ or the Laspeyres volume index is matched with the Paasche price index . For example, a price index, 1.05 representing a 5 per cent change multiplied by a volume index of 1.08, an 8 per cent change, yields a value change index of 1.134, a 13.4 per cent change.

Laspeyres and Paasche indices reflects the combined effects

~~18.20~~18.23 This relationship can be exploited whenever the total current values for both periods are known and either of a price or volume index. Suppose, for example, compilers want to derive a volume index. Laspeyres and Paasche volume indices are derived by dividing (deflating) the value change by appropriate price indices: $L_Q = I_v / P_p$ and $P_Q = I_v / L_p$ respectively. Note that L_Q from the right-hand side of equation (2) generates a time series of Laspeyres volume indices, for periods t = 1,…,T of:

$$\frac{\sum_{i=1}^{n} p_i^0 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0}, \frac{\sum_{i=1}^{n} p_i^0 q_i^2}{\sum_{i=1}^{n} p_i^0 q_i^0}, \ldots\ldots\ldots, \frac{\sum_{i=1}^{n} p_i^0 q_i^T}{\sum_{i=1}^{n} p_i^0 q_i^0} \qquad (5)$$

Multiplying through the series by the common denominator $\sum_{i=1}^{n} p_1^0 q_i^T$ yields the volume series:

$$\sum_{i=1}^{n} p_i^0 q_i^1, \sum_{i=1}^{n} p_1^0 q_1^2, \ldots\ldots\ldots, \sum_{i=1}^{n} p_1^0 q_i^T \qquad (6)$$

The relative movements from period to period for this series are identical with those of the associated Laspeyres volume indices given by (5), the two series differing only by a scalar that is the value in period 0.

~~18.21~~18.24 Series using the prices of a base year throughout, as illustrated by (6), are easy to understand but are not best practice in national accounts if the time period T is a lengthy one over which there are changes in the structure of the economy. For example, if volume changes are measured over a 10 year period, say 2010 to 2020, at constant 2010 prices, then the volume movements in later years are based on a price configuration that is likely to have changed. A better practice is to change the weights of (rebase) the Paasche deflator in 2015 and link the resulting index to the 2014 one. The resulting volume series over the 10 year

Formatted: Font: (Default) +Headings CS (Times New Roman), 10 pt, Font color: Auto, Complex Script Font: +Headings CS (Times New Roman), 10 pt, Don't snap to grid, Not Highlight period will no longer be at constant 2010 prices, but be a more representative volume index. Even better practice, resources permitting, is to form a series of annual bilateral links of constant price comparisons (see paragraphs 18.39 to 18.64). It is preferable to use the term volume series to describe such series rather than "in" or "at constant prices".

The relationship between Laspeyres and Paasche indices

~~18.22~~18.25 Before considering other possible formulae, it is useful to establish the behaviour of Laspeyres and Paasche indices vis-à-vis each other. In general, a Laspeyres index tends to register a larger increase over the base year than a Paasche index, that is, in general:

both $L_P > P_P$ and $L_Q > P_Q$ (7)

It can be shown that relationship (7) holds whenever the price and quantity relatives (weighted by values) are negatively correlated, that is, as prices go up the quantities purchased go down or vice versa. Such negative correlation is to be expected for price takers, including consumers and firms purchasing intermediate inputs, who react to changes in relative prices by substituting goods and services that have become relatively less expensive for those that have become relatively more expensive. A positive correlation would be expected for price setting firms that substitute output towards goods and services that have become relatively more expensive. In such circumstances the inequalities in equation (7) would be reversed.

~~18.23~~18.26 Consumers are assumed to maximize utility, which in turn is related to combinations of goods and services purchased. Theoretical cost of living indices (COLIs) are defined as the ratio of the minimum expenditures required to enable a consumer to attain a fixed level of utility under the two sets of prices. The COLI increases if it becomes more expensive to maintain the same level of utility. A Laspeyres COLI would hold the preferences and utility fixed in the reference period and a Paasche COLI would hold them fixed in the current period.

~~18.24~~18.27 The Laspeyres price index provides an upper bound to the oretical Laspeyres COLI. Under the COLI, consumers can substitute products that have become relatively less expensive for ones that have become relatively more expensive to obtain the same level of utility, whereas the fixed basket Laspeyres index does not allow such substitution. Similarly, the Paasche index can be shown to provide a lower bound to the theoretical Paasche COLI.

Other index number formulae

~~18.25~~18.28 Because different formulae give different results, a consideration of alternative approaches to choosing among them is needed and this in turn gives rise to a consideration of further index number formulae.

~~18.26~~18.29 It is apparent from the Laspeyres and Paasche price indices in equations (1) and (3) that both indices hold the basket of quantities fixed. The formulae differ in that Laspeyres holds the basket fixed in the reference period and Paasche in the current period. If the objective is simply to measure the price change between the two periods considered in isolation, there is no reason to prefer the basket of the earlier period to that of the later period, or vice versa. Both baskets are equally justifiable from a conceptual point of view. Thus, although they yield different results, neither formula can be judged superior to the other.

~~18.27~~18.30 A compromise solution for the price index is to use a formula that makes symmetric use of the base and current period information on quantities. The Fisher index can be shown to be the most suitable in this regard. (For an explanation of why this is so, see chapter 15 of the PPI manual.) The Fisher index (F) is defined as the geometric mean of the Laspeyres and Paasche indices, that is, for price and quantity indices respectively:

$F_P = \{L_P.P_P\}^{1/2}$ and $F_Q = \{L_Q.P_Q\}^{1/2}$ (8)

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~~18.28~~18.31 Economic theory postulates indifference curves that show how consumers would alter their expenditure patterns in response to changes in prices. Unless the utility functions the indifference curves represent are similar in periods 0 and t, a Laspeyres and a Paasche index for this period will each refer to a differently shaped utility function. In general, the Laspeyres index will provide an upper bound to its underlying utility function while the Paasche index will give a lower bound to its underlying utility function but the two utility functions will be different.

~~18.29~~18.32 In order to resolve this dilemma, a series of indices called superlative indices have been derived that relate to utility functions that adapt over time to the changes in quantities brought about by changes in prices. The Fisher index is one example of a superlative index; a Törnqvist index is another example. A Törnqvist index is the geometric average of the price relatives weighted by average expenditure shares in two periods. Thus the Törnqvist price and volume indices are defined as:

$$T_P = \prod_{i=1}^{n} \left(\frac{p_i^t}{p_i^0}\right)^{(s_i^0 + s_i^t)/2} \quad and \quad T_Q = \prod_{i=1}^{n} \left(\frac{q_i^t}{q_i^0}\right)^{(s_i^0 + s_i^t)/2} \qquad (9)$$

Both Fisher and Törnqvist indices utilize and attach equal importance to information on the value shares in both periods for weighting purposes. For this reason they may be expected to lie between the bounds of Laspeyres and Paasche indices, as is desired. The difference between the numerical values of the Törnqvist and Fisher indices and other such symmetric indices is likely to be very small. Neither Törnqvist or Fisher volume indices use the prices of a specific single period. The term “at constant prices” is a misnomer for such series; the correct term is a series in volume terms.

~~18.30~~18.33 The above analysis has been from the consumer’s or purchaser’s perspective. Economic theory also defines Laspeyres and Paasche bounds from the producer’s perspective. Revenue maximizing producers are expected to increase the relative quantities they produce in response to increases in relative prices. The resulting LaspeyresPaasche bounds are the reverse of those described above, as quantities produced are substituted towards commodities with above average changes in prices. But the implication for removing substitution bias by the use of Törnqvist and Fisher indices still holds.

Desirable index number characteristics

~~18.31~~18.34 There are two frequently quoted characteristics that it is felt index numbers for deflating national accounts should satisfy. These are the “time reversal” and “factor reversal” tests. The time reversal test requires that the index for period t compared with period 0 should be the reciprocal of that for period 0 compared with t. The factor reversal test requires that the product of the price index and the volume index should be equal to the proportionate change in the current values. It follows from the discussion in the preceding section that Laspeyres and Paasche indices on their own do not pass either of these tests. However, it follows from the definitions of Fisher indices in (8) that the Fisher index does pass these tests.

~~18.32~~18.35 The Fisher index therefore has a number of attractions that have led it to be extensively used in general economic statistics. Indeed, Fisher described his index as “ideal”. However, the Fisher index requires both reference and current period information for weights, which may affect the timeliness of the index, nor is it as easy to understand as Laspeyres or Paasche indices.

~~18.33~~18.36 The PPI manual provides in chapters 15, 16 and 17 an extensive account of the various approaches to choosing among index numbers. Also included in chapter 16 is the stochastic approach that favours the Törnqvist index. What is apparent from this extensive body of work is that all three approaches favour the Fisher index; that superlative indices such as the Fisher and Törnqvist indices produce very similar results and can all be justified from the economic theoretical approach and that the difference between superlative indices and the Laspeyres or Paasche indices, or their spread, is due to substitution bias.

Index numbers in practice

~~18.34~~18.37 The Laspeyres price index in equation (1) has the same price and weight reference period 0. In practice, especially for CPIs where timeliness is of the essence, the price reference period 0 differs from the earlier weight reference period, say *b*, since it takes time to compile the results from the survey of households, establishments and other sources for the weights to use in the index. The Laspeyres index given by the first expression in equation (1) may have as its weights S_i^b instead of S_i^0 . This index is a Young index and, like the Laspeyres index, has the undesirable property of failing the time reversal test.

~~18.35~~18.38 Statistical offices often try to overcome this by adjusting the value shares used as weights by the changes in prices between *b* and 0 to form a Lowe index given by:

$$L_{oweP} = \frac{\sum_{i=1}^{n}\left(\frac{p_i^t}{p_i^0}\right)\left(\frac{p_i^0}{p_i^b}\right)v_i^b}{\sum_{i=0}^{n} v_i^b\left(\frac{p_i^0}{p_i^b}\right)} \equiv \frac{\sum_{i=1}^{n} p_i^t q_i^b}{\sum_{i=1}^{n} p_i^0 q_i^b} \qquad (10)$$

3. Chain indices

The rebasing and linking of indices

~~18.36~~18.39 As noted in the previous section, over time the pattern of relative prices in the base period tends to become progressively less relevant to the economic situations of later periods to the point where it becomes unacceptable to continue using them to measure volume changes from one period to the next. It is then necessary to update the weights. With long time series, it is as inappropriate to use the most current weights for a date long in the past as it is to use the weights from a long time in the past for the current period. It is therefore necessary to link the old series to the new reweighted series by multiplication. This is a simple numerical operation requiring estimates for an overlapping period of the index or series calculated using both the old and new weights.

~~18.37~~18.40 The linking calculation can be undertaken in a number of ways. The current index on the new weights can be multiplied by a linking coefficient of the old to new index to convert the new index to the old index reference period. Alternatively, the index may have its reference period changed at the time of the introduction of new weights and the old index may be revised by dividing it by the linking coefficient. The process of linking an old series and a new one by means of a link for an overlap period is referred to as chaining. Numerical examples of linking and other chain index calculations are available in chapter 8 of Quarterly National Accounts Manual.

~~18.38~~18.41 Whether the chaining is done so as to preserve the earlier reference period in the new series or to change the reference period of the old series to the new one, the calculations have to be undertaken at each level of aggregation. Each component as well as each aggregate has to be linked individually because of non-additivity.

Chaining each period

~~18.39~~18.42 The more frequently weights are updated the more representative will the resulting price or volume series be. Annual chain indices result from compiling annual indices over two consecutive years each with updated weights. These “links” are combined by successive multiplication to form a series. In order to understand the properties and behaviour of chain indices in general, it is necessary to establish first how chain Laspeyres and Paasche indices behave in comparison with fixed base indices.

Chain Laspeyres and Paasche indices

~~18.40~~18.43 A chain Laspeyres volume index, L_Q, connecting periods 0 and t, is an index of the following form:

$$L_Q = \frac{\sum_{i=1}^{n} p_i^0 q_i^1}{\sum_{i=1}^{n} p_i^0 q_i^0} \times \frac{\sum_{i=1}^{n} p_i^1 q_i^2}{\sum_{i=1}^{n} p_i^1 q_i^1} \times \ldots, \frac{\sum_{i=1}^{n} p_i^{t-1} q_i^t}{\sum_{i=1}^{n} p_i^{t-1} q_i^{t-1}} \qquad (11a)$$

The corresponding chain Paasche volume index, PQ, has the following form:

$$P_Q = \frac{\sum_{i=1}^{n} p_i^1 q_i^1}{\sum_{i=1}^{n} p_i^1 q_i^0} \times \frac{\sum_{i=1}^{n} p_i^2 q_i^2}{\sum_{i=1}^{n} p_i^2 q_i^1} \times \ldots, \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^t q_i^{t-1}} \qquad (11b)$$

Laspeyres and Paasche price indices are obtained by interchanging the p's and q's in the expressions for the volume indices.

18.41 18.44 In general, if fixed base indices are replaced by chain indices, the index number spread between Laspeyres and Paasche is likely to be greatly reduced. Chain indices thus have an advantage over fixed base ones. The relationship between a fixed base index and the corresponding chain index is not always the same, however, as it depends upon the paths followed by individual prices and quantities over time.

18.42 18.45 If individual prices and quantities tend to increase or decrease steadily over time it can be shown that chaining will significantly reduce the index number spread, possibly almost eliminating it. Chapters 9 and 19 of the PPI manual provides illustrative examples and chapter 15 explains the theory underlying these findings

18.43 18.46 On the other hand, if individual prices and quantities fluctuate so that the relative price and quantity changes occurring in earlier periods are reversed in later periods, chaining will produce worse results (in comparison with the Fisher index) than a simple index.

18.44 18.47 On balance, situations favourable to the use of chain Laspeyres and Paasche indices over time seem more likely than those that are unfavourable. The underlying economic forces that are responsible for the observed long-term changes in relative prices and quantities, such as technological progress and increasing incomes, do not often go into reverse. Hence, it is generally recommended that annual indices be chained. The price and volume components of monthly and quarterly data are usually subject to much greater variation than their annual counterparts due to seasonality and short-term irregularities. Therefore, the advantages of chaining at these higher frequencies are less and chaining should definitely not be applied to seasonal data that are not adjusted for seasonal fluctuations.

Annually chained quarterly Laspeyres-type indices

18.45 18.48 Quarterly chain indices can be constructed that use annual weights rather than quarterly weights. Consider a quarterly Laspeyres-type volume index that measures the volume change from the average of year *y-1* to quarter *c* in year *y*.

$$L_Q^{\overline{(y-1)}\rightarrow(c,y)} = \frac{\sum_i P_i^{y-1} q_i^{c,y}}{\sum_i P_i^{y-1} Q_i^{y-1}} = \sum_i \frac{q_i^{c,y}}{Q_i^{y-1}} s_i^{y-1} \qquad (12a)$$

The upper case letters *P* and *Q* denote average quarterly values over a year, while *p* and *q* denote specific quarterly values. The superscripts denote the year (*y*) and quarter (*c*). $P^{y\square1}$ denotes the average price of item *i* in year *y-1*

and $p_{c,y\square1}$ denotes the price of item *i* in quarter *c* of year *y-1* 1

and $s^{y\square1}$ is the base period value share, that is the share of item *i* in the total value in year *y-1*.

Thus:

$$P_i^{y-1} = \frac{\sum_c p_i^{c,y-1} q_i^{c,y-1}}{\sum_i q_i^{c,y-1}} \;;\; Q_i^{y-1} = \frac{\sum_c q_i^{c,y-1}}{4} \;;\; and$$

$$S_i^{y-1} = \frac{P_i^{y-1}\, Q_i^{y-1}}{\sum_i q_i^{c,y-1}} = \frac{\sum_c p_i^{c,y-1} q_i^{c,y-1}}{\sum_i \sum_c p_i^{c,y-1} q_i^{c,y-1}} \qquad (12b)$$

~~18.46~~18.49 The quarterly Laspeyres-type volume indices can then be chained together with annual links. One of two alternative techniques for the annual chaining of quarterly data is usually applied, annual overlaps and one-quarter overlaps. In addition to these two conventional chaining techniques, a third technique sometimes is used based on changes from the same period in the previous year (the “over-the-year technique”). While in many cases all three techniques give similar results, in situations with strong changes in relative quantities and relative prices, the over-the-year technique can result in distorted seasonal patterns in the chained series. While standard price statistics compilation exclusively uses the one-quarter overlap technique, the annual overlap technique may be more practical for Laspeyres-type volume measures in the national accounts because it results in data that aggregate exactly to the corresponding direct annual index. In contrast, the one quarter overlap technique and the over-the-year technique do not result in data that aggregate exactly to the corresponding direct annual index. The one-quarter overlap provides the smoothest transition between each link in contrast to the annual overlap technique, which often introduces a step between each link, that is, between the fourth quarter of one year and the first quarter of the following year.

~~18.47~~18.50 The technique of using annual overlaps implies compiling estimates for each quarter at the weighted annual average prices of the previous year, with subsequent linking using the corresponding annual data to provide linking factors to scale the quarterly data upward or downward. The technique of one-quarter overlaps requires compiling estimates for the overlap quarter at the weighted annual average prices of the current year in addition to estimates at the average prices of the previous year. The ratio between the estimates for the linking quarter at the average prices of the current year and at the average prices of the previous year then provides the linking factor to scale the quarterly data up or down. The over-the-year technique requires compiling estimates for each quarter at the weighted annual average prices of the current year in addition to estimates at the average prices of the previous year. The year-on-year changes in these volume series are then used to extrapolate the quarterly volume series of the chosen reference period.

~~18.48~~18.51 Discrepancies between an annual chain volume series and the sum of the four quarters of an annually chained quarterly volume series derived using the one-quarter overlap technique can accumulate over time. Hence, quarterly chain volume series derived this way are usually benchmarked to the corresponding annual chain volume series using a procedure that minimizes the disturbance to the quarterly volume series whilst achieving consistency with the annual chain volume series. There is discussion on this in chapter 6 of Quarterly National Accounts Manual.

~~18.49~~18.52 If annual volume series are derived from data balanced in a supply and use table expressed in the prices of the previous year as recommended in section C, then it is standard practice to benchmark quarterly data to the corresponding annual balanced estimates. The benchmarking eliminates all discrepancies between the quarterly and annual chain volume series, including those arising from the use of the one-quarter overlap technique.

~~18.50~~18.53 To conclude, chaining using the one-quarter overlap technique combined with benchmarking to remove any resulting discrepancies between the quarterly and annual data gives the best result. In many circumstances, however, the annual overlap technique may give similar results. The over-the-year technique should be avoided.

Chain Laspeyres or chain superlative indices?

~~18.51~~18.54 As explained earlier, the index number spread between Laspeyres and Paasche indices may be greatly reduced by chaining when prices and quantities move smoothly over time. In such circumstances the choice of index number formula assumes less significance as all relevant index numbers lie within the bounds of the Laspeyres and Paasche indices. Nevertheless, there may still be some advantages to be gained by choosing an index for chaining, such as the Fisher or Törnqvist, that treats both periods being compared symmetrically.

~~18.52~~18.55 Such indices are likely to approximate more closely the theoretical indices based on underlying utility or production functions even though chaining may reduce the extent of their advantages over their Laspeyres or Paasche counterparts in this respect. A chain symmetric index, such as Fisher or Törnqvist, is also likely to perform better when there are fluctuations in prices and quantities. Chain Laspeyres indices, however, do not require current period data for weights and thus may lead to more timely estimates. Retrospective studies of the difference in national accounts estimates from using chain Laspeyres as against chain Fisher or Törnqvist can help in determining the advantage of using the latter formulae.

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Annually chained quarterly Fisher-type indices

~~18.53~~18.56 Just as it is possible to derive annually chained Laspeyres-type quarterly indices, so it is possible to derive annually chained Fisher-type quarterly indices. For each pair of consecutive years Laspeyres-type and Paasche-type quarterly indices are constructed for the last two quarters of the first year, year y-1 and the first two quarters of the second year, year y. The Paasche-type quarterly indices are constructed as backward-looking Laspeyres-type quarterly indices and then inverted. This is done to ensure that the Fisher-type quarterly indices are derived symmetrically. In the forward-looking Laspeyres-type indices the annual value shares relate to the first of the two years, whereas in the backward-looking Laspeyres-type indices the annual value shares relate to the second of the two years.

$$L_q^{\overline{(y-1)}\to c} = \frac{\sum_i P_i^{y-1} q_i^c}{\sum_i P_i^{y-1} Q_i^{y-1}} = \sum_i \frac{q_i^c}{Q_i^{y-1}} S_i^{y-1} \qquad (13)$$

$$P_Q^{\overline{y}\to c} = \left[L_Q^{\overline{y}\to c}\right]^{-1} \qquad (14a)$$

$$L_Q^{\overline{y}\to c} = \frac{\sum_i P_i^{y} q_i^c}{\sum_i P_i^{y} Q_i^{y}} = \sum_i \frac{q_i^c}{Q_i^{y}} S_i^{y} \qquad (14b)$$

and q_i^c is the quantity of item *i* in quarter *c* in the second two quarters of year *y-1* or the first two quarters of year *y*.

~~18.54~~18.57 For each of the four quarters a Fisher-type index is derived as the geometric mean of the corresponding Laspeyres-type and Paasche-type indices. Consecutive spans of four quarters can then be linked using the one-quarter overlap technique. The resulting annually chained Fisher-type quarterly indices need to be benchmarked to annual chain Fisher indices to achieve consistency with the annual estimates.

~~18.55~~18.58 A difficulty arises at the end of the series because it is not possible to construct Paasche-type quarterly indices that use annual weights for the current year, at least using actual observed data. One solution is to construct “true” quarterly chain Fisher indices for the latest year or two and use these to extrapolate the annually chained Fisher-type indices. But this should only be done using seasonally adjusted data. As long as the irregular variation in quarterly price and volume relativities is not very great, quarterly chain Fisher indices of seasonally adjusted data can be expected to produce satisfactory results in most circumstances.

Chaining and data coverage

~~18.56~~18.59 One major practical problem in the construction of index numbers is the fact that products are continually disappearing from markets to be replaced by new products as a result of technological progress, new discoveries, changes in tastes and fashions, and catastrophes of one kind or another. Price and volume indices are compiled by comparing the prices or quantities of goods of the same characteristics or quality (that is, homogenous goods) over time. This is not easy in product areas such as personal computers where quality changes rapidly.

~~18.57~~18.60 Chaining helps ameliorate the problems of such constant quality comparisons since the likelihood of an overlap of a product in two consecutive price periods is almost bound to be greatest and the chain indices can accommodate the changes in weight that accompany a new and a disappearing product.

Additivity and chaining

~~18.58~~18.61 An aggregate is defined as the sum of its components. Additivity in a national accounts context requires this identity to be preserved for a volume series. Although desirable from an accounting viewpoint, additivity is actually a very restrictive property. Laspeyres volume indices are the only index number formulae considered here that are additive.

~~18.59~~18.62 A single link in a chain index is sufficient to destroy additivity even when additive indices, such as Laspeyres volume indices, are linked together. Consequently, if chain volume indices are converted into time series of values by using the indices to extrapolate the values of the base period, the index components may fail to add to aggregates in later periods. A perverse form of non-additivity can occur when the chain index for the aggregate lies outside the range spanned by the chain indices for its components, a result that may be regarded as intuitively unacceptable by many users. Whether published in monetary terms or indices, it is advisable to inform users via a footnote or other meta-data that chain volume series are not additive.

~~18.60~~18.63 There is a general tendency for the discrepancies from chaining to become larger the further a period is away from the reference year. If the reference year is chosen to be near the end of the series then the discrepancies will be relatively small for the latest quarters. Indeed, if the chain Laspeyres formula is used and if the reference year is chosen to coincide with the latest base year then the quarters following the reference year are additive. Another advantage of having the reference year near the end of chain volume series is that when they are expressed as monetary values their magnitudes do not differ greatly from the current values for the latest periods if price change is occurring at a modest rate. Maintaining this situation requires rereferencing the series every year when a new link is added to the chain and this entails revising the chain volume series for their entire lengths. Note that rereferencing entails revising levels but not growth rates.

~~18.61~~18.64 Although additivity may be preserved by never undertaking a weight change this advantage is significantly outweighed by the disadvantage of increasing irrelevance of the weights in use. Rates of change for subperiods of a series, including annual rates, can be usefully phrased in terms of contributions to change, as explained below.

Variables that change sign

~~18.62~~18.65 Index number formulae are generally not applicable to time series that can take positive, negative and zero values. Nevertheless, there are ways of deriving pseudo chain volume series expressed in terms of monetary values in such cases. The most commonly used approach is to identify two associated time series that take only positive values and are such that when differenced yield the target series. An example is the stock of inventories at the start and end of the period as opposed to the change during the period. Chain volume series are not additive and so it is evident that this is an imperfect method since by construction an additive relationship is produced. It follows that the series to be differenced should be as closely aligned in terms of price and volume composition as possible with the target series. Hence, a chain volume series of changes in inventories is derived as a chain volume series of closing inventories less a chain volume series of opening inventories. Sometimes public gross fixed capital formation can take negative values as a result of the sale of assets to the private sector, in which case the chain volume series of acquisitions and sales could be differenced.

Contributions to growth

~~18.63~~18.66 When the Laspeyres formula is used and the base year and reference year coincide, the resulting volumes are additive in subsequent periods and the contribution by a component Ii to the growth of an aggregate, such as GDP, between two periods (t-n) and t can be obtained readily as follows:

$$\%\Delta_i^{(t-n)\to t} = \frac{100(I_i^t - I_i^{t-n})}{\sum_i I_i^{t-n}} \qquad (15)$$

When chain volume series are derived using either the Laspeyres formula for annual indices or the annual chaining of Laspeyres-type quarterly indices, then year-to- year or quarter-to-quarter contributions to growth can be derived easily using data expressed in the prices of the previous year prior to chaining. Such data are additive and so equation (15) can be used with *n*=1. If contributions to growth are not published by the national statistical office, the user can estimate them. Assuming the one-quarter overlap technique has been used, the formula for calculating the contribution to the percentage change from period *t-1* to period *t* is:

$$\%\Delta_i^{(t-1)\to t} = \frac{100.(I_i^t - I_i^{t-1})S_i^{t-1}}{\sum_i I_i^{t-n} s_i^{t-1}} \qquad (16)$$

where the s are the shares of the items in the total as in equations (12).

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4. Causes of price variation

Price variation due to quality differences

~~18.64~~18.67 In general, most types of goods or services, whether simple food products such as potatoes or high technology products such as computers, are available on the market in many different qualities whose physical characteristics differ from each other. For example, potatoes may be old or new, red or white, washed or unwashed, loose or pre-packed, graded or ungraded. Consumers recognize and appreciate the differences and are prepared to pay different prices. For some goods and services, such as personal computers and telecommunication services, there is a rapid turnover in the highly differentiated varieties and this, as considered below, creates severe problems for the measurement of price changes.

~~18.65~~18.68 The same generic term, such as potato, computer or transportation is used to describe goods and services that differ from each other in their price-determining characteristics. The price or quantity of a good or service of one quality cannot be directly compared to that of a different quality. Different qualities have to be treated in exactly the same way as different kinds of goods or services.

~~18.66~~18.69 Differences in quality may be attributable to differences in the physical characteristics of the goods or services concerned and be easily recognized, but not all differences in quality are of this kind. Goods or services delivered in different locations, or at different times, such as seasonal fruits and vegetables, must be treated as different qualities even if they are otherwise physically identical. The conditions of sale, or circumstances or environment in which the goods or services are supplied or delivered can make an important contribution to differences in quality. For example, a durable good sold with a guarantee, or free after-sales service is higher quality than the same good sold without guarantee or service. The same goods or services sold by different kinds of retailers, such as local shops, specialist shops, department stores or supermarkets may have to be treated as different qualities.

~~18.67~~18.70 It is generally assumed in economic analysis that whenever a difference in price is found between two goods and services that appear to be physically identical there must be some other factor, such as location, timing or conditions of sale, that is introducing a difference in quality. Otherwise, it can be argued that the difference could not persist, as rational purchasers would always buy lower priced items and no sales would take place at higher prices.

~~18.68~~18.71 When there is price variation for the same quality of good or service, the price relatives used for index number calculation should be defined as the ratio of the weighted average price of that good or service in the two periods, the weights being the relative quantities sold at each price. Suppose, for example, that a certain quantity of a particular good or service is sold at a lower price to a particular category of purchaser without any difference whatsoever in the nature of the good or service offered, location, timing or conditions of sale, or other factors. A subsequent decrease in the proportion sold at the lower price raises the average price paid by purchasers for quantities of a good or service whose quality is the same and remains unchanged, by assumption. It also raises the average price received by the seller without any change in quality. This must be recorded as a price and not a volume increase.

Price variation without quality differences

~~18.69~~18.72 Nevertheless, it must be questioned whether the existence of observed price differences always implies corresponding differences in quality. There are strong assumptions underlying the standard argument which are seldom made explicit and are often not satisfied in practice: for example, that purchasers are well informed and that they are free to choose between goods and services offered at different prices.

~~18.70~~18.73 In the first place, purchasers may not be properly informed about existing price differences and may therefore inadvertently buy at higher prices. While they may be expected to search for the lowest prices, costs are incurred in the process. Given the uncertainty and lack of information, the potential costs incurred by searching for outlets in which there is only a possibility that the same goods and services may be sold at lower prices may be greater than the potential savings, so that a rational purchaser may be prepared to accept the risk that he or she may not be buying at the lowest price. Situations in which the individual buyers or sellers negotiate, or bargain over prices, provide further examples in which purchasers may inadvertently buy at a higher price than may be found elsewhere. On the other hand, the difference between the average price of a good purchased in a market or bazaar in which individual purchasers bargain over the price and the price of the same good sold in a different type of retail outlet, such as a department store, should normally be treated as reflecting differences in quality attributable to the differing conditions under which the goods are sold.

Price discrimination

~~18.71~~18.74 Secondly, purchasers may not be free to choose the price at which they purchase because the seller may be in a position to charge different prices to different categories of purchasers for identical goods and services sold under exactly the same circumstances, in other words, to practise price discrimination. Economic theory shows that sellers have an incentive to practise price discrimination as it enables them to increase their revenues and profits. However, it is difficult to discriminate when purchasers can retrade amongst themselves, that is, when purchasers buying at the lowest prices can resell the goods to other purchasers. While most goods can be retraded, it is usually impossible to retrade services, and for this reason price discrimination is extensively practised in industries such as transportation, finance, business services, health, education, etc., in most countries. Lower prices are typically charged to purchasers with low incomes, or low average incomes, such as pensioners or students. When governments practise or encourage the practice of price discrimination it is usually justified on welfare grounds, but market producers also have reasons to discriminate in favour of households with low incomes as this may enable them to increase their profits. Thus, when different prices are charged to different consumers it is essential to establish whether or not there are in fact any quality differences associated with the lower prices. For example, if senior citizens, students or schoolchildren are charged lower fares for travelling on planes, trains or buses, at whatever time they choose to travel, this must be treated as pure price discrimination. However, if they are charged lower fares on condition that they travel only at certain times, typically off-peak times, they are being offered lower quality transportation.

The existence of parallel markets

~~18.72~~18.75 Thirdly, buyers may be unable to buy as much as they would like at a lower price because there is insufficient supply available at that price. This situation typically occurs when there are two parallel markets. There may be a primary, or official, market in which the quantities sold, and the prices at which they are sold, are subject to government or official control, while there may be a secondary market, either a free market or unofficial market, whose existence may or may not be recognized officially. If the quantities available at the price set in the official market are limited there may be excess demand so that supplies have to be allocated by rationing or some form of queuing. As a result, the price on the secondary or unofficial market will tend to be higher. It is also possible, but less likely, that lower prices are charged on the secondary or unofficial market, perhaps because the payment of taxes on products can be evaded in such a market.

~~18.73~~18.76 For the three reasons just given, lack of information, price discrimination or the existence of parallel markets, identical goods or services may sometimes be sold to different purchasers at different prices. Thus, the existence of different prices does not always reflect corresponding differences in the qualities of the goods or services sold.

~~18.74~~18.77 When there is price variation for the same quality of good or service, the price relatives used for index number calculation should be defined as the ratio of the weighted average price of that good or service in the two periods, the weights being the relative quantities sold at each price. Suppose, for example, that a certain quantity of a particular good or service is sold at a lower price to a particular category of purchaser without any difference whatsoever in the nature of the good or service offered, location, timing or conditions of sale, or other factors. A subsequent decrease in the proportion sold at the lower price raises the average price paid by purchasers for quantities of a good or service whose quality is the same and remains unchanged, by assumption. It also raises the average price received by the seller without any change in quality. This must be recorded as a price and not a volume increase.

~~18.75~~18.78 It may be difficult to distinguish genuine price discrimination from situations in which the different prices reflect differences in quality. Nevertheless, there may be situations in which large producers (especially large service producers in fields such as transportation, education or health) are able to make the distinction and provide the necessary information. If there is doubt as to whether the price differences constitute price discrimination, it seems preferable to assume that they reflect quality differences, as they have always been assumed to do so in the past.

5. The measurement of changes in quality over time

~~18.76~~18.79 Goods and services and the conditions under which they are marketed are continually changing over time, with some goods or services disappearing from the market and new qualities or new goods or services replacing them. National accountants use disaggregated price indices to deflate changes in consumption, production and investment values as the principle means of determining volume changes in such aggregates. Deficiencies in price indices carry over to estimates of volume changes. For example, estimates of price indices for computers that do not fully incorporate the increases in quality over time will overstate price changes and understate volume changes. National accountants need to be aware of the extent and nature of methods used by price compilers to take account of such quality changes, if they are to use them properly as deflators. This in turn requires that price compilers keep explanatory notes on such methods used, a policy advocated by chapter 7 of the CPI manual and chapter 8 of the PPI manual.

~~18.77~~18.80 There are, of course, costs associated with implementing quality adjustment procedures tailored to the specific product groups. What is important for national accountants and price index compilers to appreciate is that quality change is an increasing feature of product markets. The default procedures of dealing with quality change, specifically by treating all replacements as comparable, or dropping varieties from the sample if missing, implicitly incorporate valuations of quality differences. Such valuations are unlikely to be appropriate and improvements can and should be made.

~~18.78~~18.81 An unfortunate common procedure to deal with missing values is to carry forward the price from the previous period into the current period. This may well bias the index and is strongly discouraged.

~~18.79~~18.82 A brief overview of some of the more common techniques follows. More extensive discussion can be found in all the three price manuals, those for CPI, PPI and XMPI. The techniques can be divided into those that are direct or explicit methods and those that are indirect or implicit.

Direct methods

~~18.80~~18.83 In principle, the price relatives that enter into the calculation of inter-temporal price indices should measure pure price changes by comparing the prices of a representative sample of identical goods and services in different time periods. This is called the matched-models method. Price index compilers maintain detailed product descriptions of the items being priced in successive periods to ensure proper matching. When a model is missing because it is obsolete, a problem of quality adjustment arises. A number of methods can be used to take account of the quality change in order to continue the series.

~~18.81~~18.84 One possibility is to use the estimated relative costs of production as the basis for estimates of their relative prices and hence their relative qualities. It may often be feasible for producers to provide such estimates. If, however, the new quality feature was available as an option in the previous period, but now is a standard feature, the estimate of the valuation of the quality change may be based on the (relative) price of this option.

~~18.82~~18.85 An extension of the costs of production approach is known as model pricing. It is often applied to products made to order. A particular case in point is measuring building costs. The characteristics of buildings and other structures are so variable that it may be almost impossible to find identical buildings and structures being produced in successive periods of time. In these circumstances, a small number of hypothetical and relatively simple standard buildings and structures may be specified and their prices estimated in each of the periods. The specifications of these standard buildings or structures are chosen on the advice of construction experts who are also asked to estimate what their prices would be in each of the periods. Model pricing for services is described in Methodological Guide for Developing Producer Price Indices for Services. (Eurostat and the Organisation for Economic Co-operation and Development, 2005)

Hedonics

~~18.83~~18.86 A more general and powerful method of dealing with changes in quality is to make use of estimates from hedonic regression equations. Hedonic regression equations relate the observed market prices of different models to ~~certain~~ measurable price-determining characteristics. Provided sufficiently many differentiated models are on sale at the same time, the estimated regression equation can be used to determine by how much prices vary in relation to each of the characteristics or to predict the prices of models with different mixes of characteristics that are not actually on sale in the period in question.

~~18.84~~18.87 Hedonic regression equations have been estimated for high technology goods such as computers and electronic goods and for services such as air transportation. The technique has also been used for housing by regressing house prices (or rents) on characteristics such as area of floor space, number of rooms or location. The method has been used not only for inter-temporal price measurements for goods but also for services in the index. ~~The assumptions behind such imputations are less soundly based than those behind the more targeted imputation. In either case, items subject to quality change tend to be atypical and unrepresentative, so that assuming that their prices change at the same rate as for goods or services whose characteristics do not change is questionable.~~

~~18.85~~18.88 The hedonic approach is most useful when the market does not directly reveal the price and quality characteristics, but they can be inferred from prices of many varieties with different characteristics. To implement the hedonic approach, one needs to compile a data set consisting of prices and characteristics for many varieties. A sufficiently large data set with substantial variability in the mix of characteristics allows the hedonic regression to produce estimates of the implicit prices of the characteristics. For example, extensive data on the prices and characteristics of varieties of consumer goods can often be collected from the websites of retailers with relative ease.

~~18.86~~18.89 The hedonic regression is usually conducted using a semilogarithmic form. That is, the logarithm of the price of a variety in the sample is regressed against a standard set of characteristics given by

$$\ln p = \beta_0 + z_1 \beta_1 + z_2 \beta_2 + z_3 \beta_3 + \ldots + z_n \beta_n + \varepsilon$$

where ε is an error term that is assumed to satisfy the standard set of assumptions used in regression analysis. For the semilogarithmic form, logarithms are taken only of the left-hand side variable (that is, *Price*). Each of the characteristics, z, enters the equation without taking logarithm (though it is possible for the analyst to take logarithms if it would provide a better fit). The semilogarithmic form allows the use of indicator variables (or dummy variables) that take a value of one if the variety has a feature and zero if it does not.

Commented [ED2]: This subsection has been slightly expanded to provide a better introduction to this topic which is of growing importance. The main source of new material is *Consumer Price Index Manual: Concepts and Methods* (2020 edition), paras. 6.136-6.223.

The coefficients, β, can be interpreted as the percentage or proportional change in the price associated with a one-unit change in the characteristic.

~~18.87~~18.90 There are two ways in which hedonic quality adjustments can be applied to the estimation of price indexes. The first way is described as "patching" and is a way of dealing with noncomparable product substitutions in the matched-model method. It involves making an explicit quality adjustment to the price of an old variety that has dropped out of a sample to make it comparable to the new variety that has replaced it. The second way is a more comprehensive process that is used for rapidly changing products that are experiencing substantial changes in quality within relatively short periods. That process, known as hedonic price indices, requires a sample to be drawn in each period and controls for quality differences in the hedonic regression. Hedonic price indices are discussed in the *Consumer Price Index Manual: Concepts and Methods*, 2020 edition, 6.136–6.223.

Table 18.1 Hedonic Regression Imputation of New Variety's Price

Variety/ Period	t	$t+1$	$t+2$	$t+3$	$t+4$
l	p_l^t	p_l^{t+1}	p_l^{t+2}	p_l^{t+3}	p_l^{t+4}
m	p_m^t	p_m^{t+1}	p_m^{t+2}		
n			$\breve{p}_n^{t+2}$	p_n^{t+3}	p_n^{t+4}

~~18.88~~18.91 Consider the sample for a matched model index in Table 18.1 where variety *l* is available in all periods, the "old" variety *m* is only available in periods *t*, *t* + 1, and *t* + 2, and the replacement variety *n* is only available in periods *t* + 3 and *t* + 4. Variety m's replacement n is noncomparable, so p_m^{t+2} cannot be directly compared with p_n^{t+3}. The hedonic *imputation* approach would predict the price of variety *n* in period *t* + 2 using a hedonic regression estimated in period *t* + 2 and the characteristics of the new variety *n* from period *t* + 3. Alternatively, if data are not available to support estimation of regression coefficients each period, an alternative approach would be the hedonic quality-adjustment method.

~~18.89~~18.92 The compilers of price indices should consider the limitations and challenges of implementing the hedonic approach:

a. The hedonic approach requires staff to possess sufficient expertise and understanding of regression methodology to interpret the results and diagnostic statistics of the models.

b. The estimated coefficients require regular updating, which entails updating of the data sets used to prepare estimates and updating of the estimates themselves.

c. The sample of prices and characteristics used for the hedonic adjustments need to be representative of markets during the period that the adjustments are applied.

d. The functional form and choice of variables to include in the model need to be carefully considered.

e. The resources required for gathering and maintaining the data for estimating the hedonic regressions should be considered.

f. The staff resources required for devising the specification, estimation and validation of the hedonic model and its regular updating should be considered.

Indirect methods

~~18.90~~18.93 When the two qualities are not produced and sold on the market at the same time it becomes necessary to resort to indirect methods of quantifying the change in quality between the old and new qualities. In such cases it is necessary to estimate what would be the relative prices of the old and new models, or qualities, if they were produced and sold on the market at the same time and to use the estimated relative prices to determine measures of the relative qualities.

~~18.91~~18.94 When a model is missing a replacement of a comparable quality may be found and the price comparisons continued. If there is no comparable replacement, the price in the missing period may be imputed using the measured price changes of a product group expected to experience similar price changes. Dropping the product from the calculation is equivalent to an imputation that assumes the price change for the missing model would follow those of all goods and services in the index. The assumptions behind such imputations are less soundly based than those behind the more targeted imputation. In either case, items subject to quality change tend to be atypical and unrepresentative, so that assuming that their prices change at the same rate as for goods or services whose characteristics do not change is questionable.

~~18.92~~18.95 If the replacement model is not directly comparable in quality, then the price change of the new model may be readily linked to the price series of the old one if the two models are for sale in the market at the same time, in an overlap period. The implicit assumption is that the difference in prices at the time of the overlap link is a good valuation of the difference in quality, an assumption that will not be valid if the overlap period is at an unusual point in time in the model's life cycle, for example when it is about to become obsolete and discontinued or has just been introduced at an unusually high price to obtain temporary monopoly profits in a segmented market.

Rapidly changing differentiated product markets

~~18.93~~18.96 Problems of adjusting price changes for changes in quality in product markets with a rapid turnover of differentiated varieties require special consideration. The matched model method breaks down. Models of like quality can only be compared over relatively short periods and are not representative of the overall market. The summation in index number formulae such as the Laspeyres price index in equation (1) is misleading since in period t the n items produced or consumed may be quite different from those on the market in period 0.

~~18.94~~18.97 Price index number compilers use a short-run formulation to ameliorate the difficulties of comparing the prices of like with like when there is a rapid turnover in differentiated goods and services. A Laspeyres price index, for example, comparing prices in period 0 and t, is given as:

$$L_P = \frac{\sum_{i=1}^{n} p_i^0 q_i^0 \left(\frac{p_i^{t-1}}{p_i^0}\right)\left(\frac{p_i^t}{p_i^{t-1}}\right)}{\sum_{i=1}^{n} p_i^0 q_i^0} \qquad (17)$$

~~18.95~~18.98 If a new type of good, for example a digital camera, is introduced in period t-1 to replace a non-digital one, then the compiler has only to wait for the good to be on the market for two successive periods before it can be included in the index. This provides a mechanism for changing the representative items to include the new, higher quality, item within a product category that has an assigned weight. Additional weighting information may be required to augment the weighting given to cameras within the wider group. However, a chain formulation in which weights are regularly updated would be a better mechanism to achieve this.

~~18.96~~18.99 While a chain index with a short-run formulation such as in equation (17) will ameliorate the measurement problem in markets with a rapid turnover of differentiated varieties, it cannot take account of the effect on the overall price change from period *t-1* to period t of the new variety introduced in period t and of the old model that was dropped in period *t-1*. Two successive price quotes are required to implement the formula in (17) and a chain index. Hedonic indices are a means of incorporating such affects. They can take a number of forms, but essentially the prices and values of price-determining quality characteristics, say the speed, RAM, etc. of different varieties of personal computers are collected in each period. A Paasche-type hedonic imputation (or characteristics) price index would be derived by first estimating a hedonic regression of price on quality variables based on period *t-1* data and then using the estimated coefficients to impute for *t-1* the prices of the varieties available in period *t*, including those not available in *t-1*. Prices for period *t* characteristics valued at period *t* prices can be directly compared with the estimated period *t-1* valuation of period *t* characteristics to yield a Paasche-type price index. A Laspeyres-type hedonic index can be similarly defined using an estimated period *t* regression and constant period *t-1* characteristics set, as can a Fisher-type hedonic index as a geometric mean of the two. An alternative formulation is to pool the two sets of observations in periods *0* and *t* and include a dummy variable in the hedonic regression equation to distinguish observations in one period from those in the other. The coefficient on the dummy variable would be an estimate of the price change between the two periods having controlled for the effect of quality changes.

Further elaboration

~~18.97~~18.100 A detailed account of all the methods referred to above is available in chapters 6 and 7 of the CPI manual and chapters 7 and 8 of the PPI manual. These chapters include the use of imputations, overlap prices, comparable replacements, non-comparable replacements using estimates from production costs, option costs and hedonic regressions, as well as methods for markets with a rapid turnover of differentiated varieties including short-run relatives, chaining, product augmentation and hedonic indices.

~~18.98~~18.101 Further discussion of this topic can also be found in Handbook on Hedonic Indices and Quality Adjustments in Price Indexes: Special Application to Information Technology Products (Organisation for Economic Cooperation and Development, 2004).

6. Practical advantages of compiling chain indices

~~18.99~~18.102 It has been shown on theoretical grounds that long time series of volume and price indices are best derived by being chained. The question is how often in the time series should a link occur. It has been argued that annual chaining is generally best on theoretical grounds, but what of the practicalities? There are a number of matters to consider, including data requirements, computing requirements, human resource requirements, loss of additivity, revisions and informing users.

a. If annual current values and corresponding volume or price data are available, then annual chaining is possible. No other data are required.

b. The computing requirements of deriving annual chain indices are greater than those for fixed-weighted Laspeyres-type indices and should not be attempted without adequate, tailored software, though improvements in the computational capacity of software used for compilation have made this objection less important. ~~The complexity of the software needed depends on the formula used and the method of linking. For instance, it is quite simple to develop software to derive annually chained Laspeyres-type quarterly volume measures using the annual overlap method.~~

c. Experience has shown that if the benefits of chain volume measures, along with the loss of additivity, are carefully explained to users via documentation and seminars before their introduction, chain volume measures are generally accepted. Particular attention should be given to informing the key users, including economic journalists, well beforehand.

d. When volume estimates are rebased, say every five or ten years, without chaining annually then it is typically the case that the growth rates are revised. If price and volume relativities have been changing rapidly, then the changes in the growth rates can be dramatic. Such is usually the case for any aggregate in which computers have a significant share. With annual chaining history is only "rewritten" a little each year, not in one large jump every five or ten years. Not surprisingly, the sort of big revisions associated with chaining only every five or ten years can have a detrimental effect on user confidence in the national accounts, not least because users learn they can expect similar revisions in the future. Annual chaining not only measures changes better, it is likely to increase confidence in the resulting national accounts volume indices.

C. Derivation of volume measures in the national accounts

1. Introduction

~~18.100~~18.103 This section is concerned with the application of the theory described in section B to the practice of deriving volume measures of parts of the SNA. The parts concerned are primarily the components of the goods and services account. Ideally this should be done within the context of supply and use tables, as explained below. Just as flows of capital formation can be expressed in volume terms, so can stocks of non-produced assets. It is not considered possible to separate all income flows into price and volume components but some limited measures of real income are possible, as also explained below.

~~18.101~~18.104 The ideal way of producing volume estimates of macroeconomic aggregates is to work at a very detailed level, deflating each component by a strictly appropriate price index. There are cases, though, where this approach is not possible; either appropriate price indices do not exist, or there may be inconsistencies in the current value data or the price indices, that make the results of deflation questionable. In such cases, alternative approaches must be considered including the possibility of projecting (or extrapolating) forward estimates for earlier years or using alternative indicators of the volume growth in a particular case.

~~18.102~~18.105 Once a set of volume measures is available for a given period, it needs to be presented with data for other periods in time series form. This is when chaining should be introduced for data derived by deflation of individual components. As recommended in section B, this should ideally be done annually using price indices of the previous year but if this is not possible, chaining over a longer period should be adopted. Major changes in economic structure, such as the impact of rapid fluctuations in oil prices on an oil exporting economy indicate that using the same base year before and after the change is likely to give quite misleading indications of the evolution of the economy. Chaining becomes essential rather than just desirable in such cases.

Terminology for volume estimates

~~18.103~~18.106 When time series are constructed by dividing the current values for each year at the most detailed level possible by fixed base year Laspeyres price indices, it is appropriate to describe the resulting series as being at the constant prices of the base year. (This is because as long as the work is done at a sufficiently detailed level, the result approximates using a Paasche price index.) However, when each year's value is deflated by a price index with a different base year, it is no longer strictly correct to describe the resulting time series in this way. More accurate terms are "chain volume series", "chain volume measure" or "chain volume index" if the series is expressed in index number form. If it is desirable to specify the reference year in the term, then "chain volume series in reference year [currency units]" may be used.

~~18.104~~18.107 The use of the term "at constant prices" is also inappropriate for series that are linked less frequently than annually and to volume series based on the use of Fisher or Törnqvist formulae, whose price configurations are not constant over the duration of the series. For such series the terms "volume series" or "volume index" are appropriate to describe a series or index.

~~18.105~~18.108 The change of terminology also reflects the loss of additivity of the resulting time series since only series expressed in the same set of prices throughout, for example by using Laspeyres indices, are additive.

2. Price deflation vs. quantity revaluation

~~18.106~~18.109 Volume and price indices can only be derived for variables that have price and quantity elements. All transactions involving the exchange of goods and services and the levels of stocks of non-financial assets have this characteristic but income flows and financial assets and liabilities do not. Some balancing items have the characteristic but others do not and so they need to be considered individually.

~~18.107~~18.110 While both volume and price measures are of major importance in the national accounts, the principal focus of users is on the growth rates of volume measures, rather than prices. The compilation of the national accounts in volume and current value terms reflects this priority, with the price aggregates being derived implicitly, by dividing the current values by the corresponding volumes.

~~18.108~~18.111 When independent, reliable and comprehensive data are available at current values it is generally not necessary to construct volume measures by aggregating quantity relatives. In most cases it is preferable and more practicable to use price indices to deflate current value data. Even for cases like electricity where the volume measure seems to be easily available, a direct volume measure is inappropriate because of the treatment of prices applying in different markets as explained in paragraphs ~~15~~18.69 to ~~15~~18.75. A change in the composition of the type of user leads to a change in the price and volume of electricity in the SNA even though the physical measure of electricity distributed may not have changed.

~~18.109~~18.112 As explained in section B, price information is easier to collect and aggregate than volume information because all prices are expressed in a common unit whereas volumes come in a multitude of units. Further, price relatives for a representative sample of goods and services can be used as typical for all goods and services in the same group in a way that volume measures would not be representative. More importantly, the volume changes associated with new and disappearing products can be properly reflected when current values are deflated by price indices as described in section B.

~~18.110~~18.113 For some products, for example closely specified agricultural products or minerals, it may be that the current value data have been constructed by multiplying a volume measure by an appropriate price. These are instances when there is no aggregation problem across the group of products and adjustments for quality differences are more easily and more satisfactorily made to the volume measures directly. While some such products may be of significant value in some countries, it will be a small number of the total number of products that can best be treated in this way.

~~18.111~~18.114 To obtain a Laspeyres volume measure the appropriate price index used to deflate the current value is a Paasche index and vice versa. However, the available price indices are nearly always constructed using the Laspeyres or Lowe formulae, because construction of a Paasche price index has exactly the same data requirements as the direct derivation of a Laspeyres volume index and faces the same problems. If robust current value data and Laspeyres price indices are available at a sufficiently detailed level then Paasche volume indices, at the detailed level, can be aggregated using the Laspeyres formula to obtain an approximation of a true Laspeyres volume measure of the aggregate.

~~18.112~~18.115 A Fisher volume index can be obtained either by taking the geometric mean of Laspeyres and Paasche volume indices or by deflating an index of the current values by a Fisher price index.

3. Available price indices

~~18.113~~18.116 There are four major types of price index available to derive volume measures in the national accounts: consumer price indices (CPIs), producer price indices (PPIs), export price indices (XPIs) and import price indices (MPIs). CPIs are measures of purchasers' prices and PPIs are measures of basic prices. XPIs are measures of FOB prices; MPIs may measure FOB or CIF prices.

~~18.114~~18.117 There are two defining aspects of recording transactions: timing and valuation. It is therefore critical that the price indices and the current values they are used to deflate correspond in both these aspects, as well as scope. The four types of price indices are usually available monthly and so quarterly and annual deflators can be obtained for flow and stock variables by averaging the monthly indices appropriately to centre the average at the desired valuation point. For flow variables this is usually the mid-point of the period, while for stock variables it is usually, but not always, the end of the period. For flow variables, the average price of the period should reflect known variations within the period. This is particularly important when there is a strong seasonal pattern, large irregular movements in certain months or hyperinflation. When none of these factors is present, the average price will be close to the observed price at the middle of the time period. The fact that this is frequently the case does not imply that the midperiod price is always the conceptually correct one to take, however.

4. The supply and use tables as the basis for volume measures of GDP

~~18.115~~18.118 Chapter ~~14~~ 15 describes the supply and use tables. It explains how the supply table itemizes the products each industry produces which are then identified in the use table where the allocation of each product between intermediate consumption and final demand is spelled out. Compiling supply and use tables at current values ensures consistency in the different measures of GDP. More powerfully, compiling supply and use tables in volume terms ensures that both the volumes and prices in the SNA are consistent. In principle, tables at current values and in volume terms should be compiled at the same time in order to make the best use of all the information available to the compiler.

~~18.116~~18.119 It is often the case that not all the detailed data required for compiling supply and use tables are available each period and estimates have to be made to fill the empty cells. For example, detailed data for intermediate consumption by product by industry are often collected infrequently. It is generally better to make an initial assumption of a constant composition of intermediate inputs over time in volume terms than in current values. Furthermore, adjustments to the raw and estimated data can be greatly assisted by evaluating growth rates in prices and volumes from the previous or following period. For these reasons it is recommended that supply and use tables should be compiled at current values and in volume terms at the same time and balanced simultaneously.

~~18.117~~18.120 In order to derive a set of supply and use tables in volume terms that are additive, the appropriate way to proceed is first to express the table in the prices of the previous year, that is, as Laspeyres volume indices linking the previous year to the current year, referenced to the values in the previous year. In order to obtain annual chain Fisher volume measures, it also necessary to derive supply and use tables of the previous year in the prices of the current year. Such values are in effect backward-looking Laspeyres indices referenced to the prices of the current year. Paasche volume indices are obtained by taking the inverse of the backward-looking Laspeyres indices. Fisher volume indices can then be derived as the geometric mean of the Laspeyres and Paasche volume indices between two adjacent years.

5. Volume measures of the output estimate of GDP

Market output

~~18.118~~18.121 In principle, PPIs can be compiled for all market output and then they can be used to deflate current values to obtain volume estimates.

~~18.119~~18.122 In practice, there are some products for which it is very difficult to derive price indices and special steps must be taken to derive the corresponding volume measures. A particular case is those of margin industries including financial services. Output of a margin industry is usually calculated as the margin rate times the value of a transaction. To determine a volume figure the base year rate is applied to the value of the transaction suitably deflated to base year values. As explained in section E.7 of this chapter, in the case of implicit financial services on loans and deposits, the reference rate and the rates of bank interest are used in conjunction with figures of loans and deposits deflated by the general price increase since the base year.

~~18.120~~18.123 In other cases where there is no suitable deflator to apply to a current value, volume indices may be derived by extrapolating the current values in the base period by suitable indicators.

Non-market output of government and NPISHs

~~18.121~~18.124 The current value of the output of non-market goods and services produced by government units or NPISHs is estimated on the basis of the sum of costs incurred in their production, as explained in chapter ~~6~~7. This output consists of individual goods and services delivered to households and collective services provided to the community as a whole. The fact that such output is valued on the basis of the value of inputs needed to produce them does not mean that it cannot be distinguished from the inputs used to produce it. In particular, the change in the volume of output can be different from the change in the volume of inputs. Changes in productivity may occur in all fields of production, including the production of non-market services.

~~18.122~~18.125 In practice, there are three possible methods of compiling volume estimates of the output of non-market goods and services. The first is to derive a pseudo output price index such that when it is compared to the aggregate input price index the difference reflects the productivity growth thought to be occurring in the production process. Pseudo output price indices can be derived in various ways, such as by adjusting the input price index according to the observed productivity growth of a related production process or by basing the growth of the pseudo output price index on the observed output price indices of similar products.

However, such data are rarely available for the goods and services produced by government and NPISHs.

~~18.123~~18.126 The second approach, the "output volume method," is recommended for individual services, in particular, health and education. It is based on the calculation of a volume indicator of output using adequately weighted measures of output of the various categories of non-market goods and services produced. These measures of output should fully reflect changes in both quantity and quality.

~~18.124~~18.127 The third approach, called the "input method", may be used for collective services such as defence for which the "output volume method" is hardly applicable because there are, in general, no adequate quality-adjusted quantity measures of output. The "input method" consists of measuring changes in output by changes in the weighted sum of volume measures of all the inputs. The latter should fully reflect both changes in quantity and quality. They are generally best derived by deflating the various input costs by corresponding constant-quality price indices, or when such price indices are unavailable, using volume indicators that reflect input volume change (for example, number of hours worked by employees).

~~18.125~~18.128 It is useful at this stage to define the terms input, activity, output and outcome. Taking health services as an example, input is defined as the labour input of medical and non- medical staff, the drugs, the electricity and other inputs purchased and the depreciation of the equipment and buildings used. These resources are used in the activity of primary care and in hospital activities, such as a general practitioner making an examination, the carrying out of a heart operation and other activities designed to benefit the individual patient. The benefits to the patient constitute the output associated with these input activities. Finally there is the health outcome, which may depend on a number of factors apart from the output of health care, such as whether or not the person gives up smoking.

~~18.126~~18.129 The measurement of the volume of output of non-market individual services should avoid two pitfalls. The first of these is that it should not be restricted to reflect the inputs or the activity of the unit producing the services. Inputs are not an appropriate measure and while activities may be the only available indicator and hence have to be used, they too are an intermediate variable. What should be measured is the service rendered to the customer. The second risk is that if outcome is defined in terms of the welfare objectives of the non-market service (for example, changes in the quality of health for the measurement of the health service, or changes in the quality of education for the measurement of the education service) the change in the volume of the output of the non-market unit cannot be reflected by the change in the indicators of outcome. This is because indicators of outcome can be affected by other aspects that are not directly related to the activity of the non-market services. For example, in the case of health, it is well- known that there are many factors other than the output of the non-market health units, such as sanitation, housing, nutrition, education, consumption of tobacco, alcohol and drugs, pollution, whose collective impact on the health of the community may be far greater than that of the provision of health services. Similarly, the output of education services is quite different from the level of knowledge or skills possessed by members of the community. Education services consist principally of teaching provided by schools, colleges, universities to the pupils and students who consume such services. The level of knowledge or skills in the community depends in addition on other factors, such as the amount of study or effort made by consumers of education services and their attitudes and motivation.

~~18.127~~18.130 In the light of these observations, the "output volume method" is the recommended method for compiling indicators of volume change of non-market services. The method is based on quantity indicators, adequately quality- adjusted, weighted together using average cost weights. Two criteria should be respected to compile adequate indicators of volume change. In the first place, the quantities and costs used should reflect the full range of services for the functional area under review and cost weights should be updated regularly. If part of the costs of the functional area is not covered by the quantity indicator, it should not be assumed that the uncovered part follows the changes of the part that is covered. If no direct output volume method is applicable for this part, an input method should be used for it. Secondly, quantity indicators should be adjusted for quality change. For example, services should be sufficiently differentiated with the aim of arriving at categories that can be regarded as homogeneous. An aspect of quality change is then captured by changes in the proportions of different categories if the weights assigned to each category are frequently updated. In addition, the quantity indicator of each category can be augmented by an explicit quality adjustment factor. One way of identifying explicit quality adjustment factors is by reviewing the effects that the service has on measures of outcome. When feasible, direct volume measures should be preferred for individual non-market services as described in the *Handbook on prices and volume measures in national* *accounts* (Eurostat, 2016) or the handbook *Towards measuring the volume of health and education and services* (Organisation for Economic Co-operation and Development, 2009). Compilers should take account that quite some progress has been made to derive volume estimates of output, especially for education and health, that take account of changes in the quality as well as the quantity of the services provided.

~~18.128~~18.131 It is recommended these volume indicators be tested for a substantial period of time with the aid of experts in the domain prior to their incorporation in the national accounts. Expert advice is particularly relevant in the areas of health and education, which usually dominate the provision of individual services. Further, the consequences of the estimates including the implications for productivity measures should be fully assessed before adoption. Unless and until the results of such investigations are satisfactory, it might be advisable to use the second best method, the “input method”.

~~18.129~~18.132 Measuring changes in the volume of collective services is generally more difficult than measuring the volume changes in individual services because the former are hard to define and to observe. One reason is that many collective services are preventative in nature, protecting households or other institutional units from acts of violence including acts of war, or protecting them from other hazards, such as road accidents, pollution, fire, theft or avoidable diseases are concepts that are difficult to translate into quantitative measures. This is an area in which further research is needed.

~~18.130~~18.133 When it is not possible to avoid using an input measure as a proxy for an output measure, the input measure should be a comprehensive one, it should not be confined to labour inputs but cover all inputs. In addition, explanatory information should accompany the national estimates that draw users’ attention to the methods of measurement.

Output for own final use

~~18.131~~18.134 Output for own final use falls into two categories, goods produced and consumed by households and fixed assets produced for own use. Included in the above are changes in inventories of finished goods and work-in-progress.

~~18.132~~18.135 For most output for own final use the use of pseudo output price indices is an effective, low-cost option. For goods produced and consumed by households, CPIs are likely to be available for similar goods. (However, for agricultural output grown and consumed by households, the price index used should not include any margins or taxes not actually incurred.) Similarly, there are likely to be output price indices available for fixed assets such as equipment, buildings and structures produced for own use as capital formation. For some types of fixed asset produced on own account there may be no output price indices available for similar products and different strategies may need to be considered. This is discussed further in the section on gross fixed capital formation.

Intermediate consumption

~~18.133~~18.136 As noted earlier, the most robust way of estimating intermediate consumption in volume terms is within the framework of a supply and use table in volume terms where information on volume growth rates as well as price information may be used.

~~18.134~~18.137 Countries that compile PPIs generally do so for outputs, though countries with developed statistical systems may also compile input PPIs. Such input PPIs are directly applicable to the deflation of intermediate consumption.

~~18.135~~18.138 If input PPIs are not compiled, output PPIs, MPIs and, to a limited extent, CPIs may be used instead. Intermediate consumption is valued at purchasers’ prices, while output PPIs are valued at basic prices. There is thus a margin between the valuation of goods used as intermediate consumption at purchasers’ prices and output PPIs, which is accounted for by transportation costs (unless the producer provides these services without a separate invoice), possible insurance costs, wholesale and retail trade margins and taxes less subsidies on products. The size of this margin will depend on circumstances. Often trade margins on goods for intermediate consumption are much smaller than for final consumption and the taxes may be smaller under a VAT system. For services used as intermediate consumption, the difference in valuation usually consists of only taxes less subsidies on products.

~~18.136~~18.139 Chapter ~~14~~ 15 describes how the intermediate consumption part of the use matrix can be partitioned to show the domestic inputs at basic prices, imports, margins and taxes separately. If this information is available, the quality of the resulting deflation exercise will be improved since it will not be necessary to use the assumption that import, tax and margin proportions apply uniformly across the elements of the rows of the use matrix.

Gross domestic product and gross value added

~~18.137~~18.140 When gross domestic product (GDP) is derived by summing final domestic expenditures and exports and subtracting imports, or by subtracting intermediate consumption from output and adding taxes less subsidies on products, volume measures of GDP can be obtained provided that the volumes being aggregated are additive, (that is, are based on the Laspeyres formula).

~~18.138~~18.141 Central to the production measure of GDP is value added, the balancing item in the production account. The most common practice is to deflate the values of output and intermediate consumption independently, industry by industry, and then derive the difference as value added for each industry. (This is known as the double deflation method.) Different price indices are necessary for two reasons. The first is because the goods and services included in intermediate consumption for any industry are not the same as the output of that industry. The second reason is that intermediate inputs are always measured at purchasers' prices whereas output is measured at either basic prices or producers' prices.

Commented [ED3]: Paragraph drawn from para. 18.27 of *2008 SNA*.

~~18.139~~18.142 The gross value added of an establishment, enterprise, industry or sector is measured by the amount by which the value of the outputs produced by that establishment, enterprise, industry or sector exceeds the value of the intermediate inputs consumed. This may be written as:

$$\sum PQ - \sum pq \qquad (18a)$$

where the Q's refer to outputs, P's their basic prices, q's to intermediate inputs and p's their purchasers' prices. Value added in year t at prices of year t is given by:

$$\sum P^t Q^t - \sum p^t q^t \qquad (18b)$$

while value added in year t at the prices of the base year, 0, is given by:

$$\sum P^0 Q^t - \sum p^0 q^t \qquad (18c)$$

This measure of value added is generally described as being obtained by "double deflation" as it can be obtained by deflating the current value of output by an appropriate (Paasche-type) price index and by similarly deflating the current value of intermediate consumption.

~~18.140~~18.143 While the double deflation method is theoretically sound, the resulting estimates are subject to the errors of measurement in the volume estimates of both output and intermediate consumption. This may be especially true if output PPIs are applied to inputs, many of which are imported. Because value added is the relatively small difference between two much larger figures, it is extremely sensitive to error. It is therefore advisable to compare the growth rates of the price and volume measures of value added over recent years with the corresponding growth rates of output and intermediate inputs and, if possible, with volume estimates of inputs of labour and capital services to check for plausibility.

~~18.141~~18.144 Because of the possible problems in trying to estimate value added using the double deflation approach, it is also common to estimate the volume movements of value added directly using only one time series, that is a "single indicator" method instead of double deflation. One such single indicator method is to extrapolate value added in proportion to the volume changes in the corresponding levels of output.

~~18.142~~18.145 The choice to be made between the use of a single indicator method (which may yield biased results) or a double deflation method (which may yield volatile results) must be based on judgement. The same choice need not be made for all industry groups. Further, the single indicator method may be used for quarterly figures until the year is complete and better double deflation estimates are available.

~~18.143~~18.146 In certain non-market service industries, it may be necessary to estimate movements in the volume of value added on the basis of the estimated volume changes of the inputs into the industries. The inputs may be total inputs, labour inputs on their own or intermediate inputs on their own. For example, it is not uncommon to find the movement of the implicit volume of value added estimated by means of changes in remuneration of employees at constant wage rates, or even simply by changes in numbers employed, in both market and non-market service industries. (There is extensive work being carried out to improve these working assumptions by trying to measure the outputs of government-provided health and education more objectively.)

~~18.144~~18.147 Compilers of data may be forced to adopt such expedients, even when there is no good reason to assume that labour productivity remains unchanged in the short- or long-term. Sometimes, volume changes for intermediate inputs may be used, for example, short-term movements in value added in real terms for the construction industry may be estimated from changes in the volume of building materials consumed such as cement, bricks, timber, etc. The use of indicators of this kind may be the only way in which to estimate short-term movements in output or value added, but they are not acceptable over long time periods.

~~18.145~~18.148 There is also interest in trying to associate movements in value added, after price effects have been eliminated, with changes in labour and capital inputs. These measures of multifactor productivity are discussed in Section F.3 of this chapter.

6. Volume measures of the expenditure estimate of GDP

~~18.146~~18.149 The measure of GDP easiest to express in volume terms is that of expenditure. As long as appropriate price indices exist, the estimates of final consumption expenditure of households, general government and NPISH, capital formation, exports and imports can be deflated without much conceptual difficulty. It is desirable to work at as great a degree of detail as possible using the product detail available for each aggregate. Care must be taken, as explained in section B.5 of this chapter, to ensure that differences in quality are properly accounted for in the price deflators. This is especially important in the case of capital formation where many items such as computers are subject to rapid technological change and many items are customized, for example large construction projects or pieces of heavy machinery built to individual specifications.

~~18.147~~18.150 Each of the components of the expenditure estimate of GDP should be expressed in volume terms. The main approaches to deriving these estimates are described in turn below.

Household final consumption expenditure

~~18.148~~18.151 Household consumption expenditure should be deflated at as detailed a degree as possible. In general this will involve making use of CPIs though care is needed to ensure that the coverage of the CPI being used matches the category of consumption expenditure being deflated. Even where detailed estimates of consumption expenditure are not compiled from household surveys and other primary sources, having an estimate of household consumption expenditure by type of product from a supply and use table for deflation will significantly improve the estimate of consumption expenditure in volume terms as compared with the single deflation of a total figure only.

~~18.149~~18.152 A major component where CPIs are unlikely to be available is the measure of the rental services of owner-occupied dwellings. Three alternative approaches are outlined in chapter 11 of the CPI manual, but only the use- based approach is recommended for measuring the consumption of housing services in the national accounts. This approach can take either a user-cost formulation that attempts to measure the changes in the cost to owner- occupiers of using the dwelling, or a rental-equivalence formulation based on how much owner-occupiers would have to pay to rent their dwellings. The latter method is more generally adopted for CPIs.

Commented [ED4]: This paragraph is an abbreviated version of para. 18.28 of *2008 SNA*.

Commented [ED5]: This paragraph was moved from para. 18.25 of *2008 SNA*.

Final consumption expenditure by government and NPISHs

~~18.150~~18.153 The final consumption expenditure of general government and NPISHs consists of their non-market output less any revenue from incidental sales plus the value of goods and services purchased from market producers for onwards transmission to individual households at prices that are not economically significant less any partial payments. (The derivation of this identity is discussed in chapter ~~9~~10.)

~~18.151~~18.154 Each of these items should be expressed in volume terms separately. The problem of measuring non-market output in volume terms is discussed above. For goods and services transferred to households, the price indices used should be those paid for the goods less the proportion that households pay. If the proportion of the price paid by government (or NPISHs) alters from one year to another, this is seen as a volume change in expenditure on the part of both general government (or NPISHs) and households.

~~18.152~~18.155 Price indices for services are more difficult to compile than for goods and this is especially so for non-market services. Because the current values of non-market services are usually determined as the sum of costs, the obvious approach is to deflate each of these (including calculating remuneration of employees at constant remuneration rates). However, this does not allow for any change in the quality of services provided and in particular for the impact of any productivity changes that may have been achieved. When feasible, direct volume measures should be preferred for individual non-market services as described in *Handbook on prices and volume measures in national accounts* and *Towards measuring the volume of health and education and services*.

Commented [ED6]: Paragraph based on para. 18.26 of *2008 SNA*.

Gross fixed capital formation

~~18.153~~18.156 The availability of appropriate price indices for gross fixed capital formation varies considerably between different types of asset.

~~18.154~~18.157 There are often ~~CPIs~~ house price indices for new dwellings and PPIs for new buildings and structures. The costs of ownership transfer should be deflated separately. The current value and volume estimates are usually derived from separate estimates of the constituent parts, legal fees, transport and installation costs etc.

~~18.155~~18.158 For standard products used as capital formation, PPIs are likely to be available but much capital formation is specific to the purchaser and appropriate indices may have to be developed using the best information available.

~~18.156~~18.159 Price indices for equipment vary considerably in their growth rates. For example, price indices for computer equipment have fallen rapidly year after year while price indices for transport equipment have tended to increase. It is important in such cases that the different types of equipment are deflated separately using the matching price indices (or, equivalently, an appropriately weighted Paasche price index is used to deflate the aggregate).

~~18.157~~18.160 Intellectual property products are generally not well covered by available price indices. There are several reasons for this. One is that many intellectual products are produced for own use and there may be no observed market prices. Another is that intellectual property products are very heterogeneous. However, these are not insurmountable difficulties and there are strategies for addressing them. As examples, the two major items in this category, software and databases and research and experimental development, are considered. Techniques for deriving volume measures of software and databases are described in section E of this chapter, with additional guidance on measuring the prices and volumes of software and data provided in section E of chapter 22. For research and experimental development (R&D), although it is often undertaken on own account, given its heterogeneous nature the choice for deflation lies between deriving pseudo output price indices and using input price indices.

~~Research and experimental development (R&D) is another activity that is often undertaken on own account. However, given the heterogeneous nature of R&D, the choice for deflation lies between deriving pseudo output price indices and using input price indi~~

Changes in inventories

~~18.158~~18.161 Although changes in inventories may be small relative to other components of GDP, the fact that their relative size might change quite significantly from one period to the next means that they can make a significant contribution to changes in ~~the size of~~ GDP particularly in the quarterly national accounts. For this reason, the calculation of changes in inventories in volume terms is particularly important. However, it is also a challenging task. As noted in paragraph ~~15.62,~~ 18.62, because changes in inventories can take positive, negative or zero values, a chain index should not be derived directly. Chain volume estimates of changes in inventories should be derived by first deriving chain volume estimates of the opening and closing stocks of inventories and then differencing them.

~~18.159~~18.162 Volume estimation should be undertaken at a detailed level for different types of inventories, (work-in-progress, finished goods, materials and supplies, goods for resale). Deflation of stocks of inventories must be related to the composition of those inventories in terms of products rather than to the industry holding those inventories. PPIs, MPIs, CPIs and labour cost indices are all commonly used in deriving deflators, with adjustments to the appropriate valuation basis. It is important to understand how enterprises value their inventories as this can provide information on not only the type of products but also the average length of time over which goods are kept in inventories.

~~18.160~~18.163 When goods are sent abroad for processing without a change of ownership, it must be remembered that some inventories may be held outside the national territory but national prices should be applied to them to derive their corresponding volumes.

Acquisition less disposal of valuables

~~18.161~~18.164 National statistical offices generally do not compile specific price indices for valuables. The major constituents should be deflated using the most suitable price indices available.

Exports and imports

~~18.162~~18.165 Exports and imports consist of both goods and services. For both exports and imports, goods and services are expressed in volume terms using quite different deflators because of the very different sources available for goods and services. Improvements have been made to price indices for external trade in services that have led to improved data in this area.

~~18.163~~18.166 The valuation of imports and exports of goods is discussed in chapter ~~14~~15. In principle, they should be valued when change of ownership between a resident unit and a non- resident owner takes place and include or exclude transportation costs according to whether the supplier does not or does include transportation to the purchaser in the price charged. In practice, however, many countries are dependent for data on imports and exports of goods on customs declarations that value imports on a CIF basis but exports on a FOB basis. This assumes that change of ownership always takes place at the border of the exporting country. For balance of payments purposes, imports of goods should be converted to a FOB basis also but this is usually done at an aggregate level and may only be disaggregated in the supply and use context if at all.

~~18.164~~18.167 Given the existence of detailed XPI and MPI for goods, it should be a simple matter to deflate the current value estimates of exports and imports of goods at as detailed a level as practical in order to approximate the use of Laspeyres volume or Paasche price indices. In order to compile detailed volume estimates of imports of goods in the supply and use tables either the CIF estimates should be put onto a FOB basis or the MPIs need to be adjusted to a CIF basis. The usual working assumption is that CIF and FOB approximate purchasers' and basic prices respectively but as explained in chapter ~~14~~15, the adequacy of the approximation depends on circumstances surrounding transport margins.

~~18.165~~18.168 XPIs and MPIs are compiled by three general methods the nature of which is largely dependent on the source data used. The first and predominant method, at least in terms of the number of countries using it, is unit value indices compiled from detailed import and export merchandise trade data derived from administrative customs documents. As pointed out in section B, unit value indices are not price indices since their changes may be due to price and (compositional) quantity changes. However, they are used by many countries as surrogates for price indices. The second method is to compile price indices using data from surveyed establishments on the prices of representative items exported and imported. The surveyed prices will be of items that are defined according to detailed specifications so that the change in price of the same item specification can be measured over time. The third method is a hybrid approach that involves compiling establishment survey-based price indices for some product groups and customs-based unit value indices for others.

~~18.166~~18.169 The case for unit value indices derived from merchandise trade figures is based on the relatively low cost of such data. Their use as deflators requires some caution as they have been shown to be subject to bias when compared with price indices. The bias in unit value indices is mainly due to changes in the mix of the heterogeneous items recorded in customs documents, but also to the often poor quality of recorded data on quantities. The former is particularly important in modern product markets given the increasing differentiation of products. Unit value indices may suffer further in recent times due to an increasing lack of comprehensiveness of the source data with increasing proportions of trade being in services and by e-commerce and hence not covered by merchandise trade data. Further, countries in customs and monetary unions are unlikely to have intra-union trade data as a by-product of customs documentation. Finally, some trade may not be covered by customs controls, such as electricity, gas and water, or be of “unique” goods, such as ships and large machinery, with profound measurement problems for unit values.

~~18.167~~18.170 As noted above, current data sources for price indices for international trade in services are less comprehensive than in other areas. If MPIs and XPIs are available for exports and imports of services they can be readily used to derive the required volume estimates. If they are not, volume estimates of exports of services can be mostly derived using an assortment of PPIs and CPIs. For example, volume estimates of freight transport services could be derived using PPIs according to the form of transport, while volume estimates of accommodation services could be derived using the appropriate CPIs. If MPIs are not available for imports of services then price indices of the countries exporting the services, adjusted for changes in the exchange rate, may have to be used.

~~18.168~~18.171 It must be remembered that if imports of goods are valued including transport services, then these transport services should be excluded from total imports of services.

7. Volumes and prices for stocks of fixed assets and ~~consumption of fixed capital~~depreciation

~~18.169~~18.172 ~~Derivation of~~ Deriving volume estimates of depreciation~~stocks~~ requires estimates of capital stock excluding the effects of price changes. The levels of capital stock are typically derived by cumulating capital formation in successive periods and deducting the amount that has been exhausted. It clearly makes no sense to aggregate estimates of capital formation at the prices actually paid since the effect of rising prices (even prices rising only moderately) will be to overstate the amount of “new” capital relative to “old”.

Commented [ED7]: These two paragraphs are based on paras. 18.31-18.32 of *2008 SNA*.

~~18.170~~18.173 The preferred technique is to estimate all capital still in stock at the price of a single year and then revalue this to the price prevailing when the balance sheet is to be drawn up, typically the first and last day of the accounting period. This should be done at the most detailed level practicable. More on this can also be found in chapter 17.

~~18.171~~18.174 Consider first a single type of fixed asset. The stock of this type of asset consists of a number of items, typically of different vintages, that are valued and aggregated with a consistent set of prices. “Consistent” is to be understood here meaning the prices relate to the same period or point in time and being based on the same price concept, such as purchasers’ prices. Measuring stocks at historical prices, that is, by adding up quantities that have been valued with prices of different periods is therefore an inconsistent valuation. It is sometimes found in enterprise accounts but does not constitute an economically meaningful measure in the context of the SNA.

~~18.172~~18.175 The price vector used to value the quantities of fixed assets has to refer to a point in time (beginning or end of period) when the values of stocks are compiled for the opening or closing balance sheets. For other purposes, quantities of assets may be valued with a price vector that refers to the average of an accounting period. For example, measures of depreciation may be derived by subtracting the closing stock of assets from the opening stock plus gross capital formation as long as average-period prices are used for each component in order to eliminate holding gains and losses (and assuming no other volume changes in assets).

~~18.173~~18.176 The process by which many capital stock measures are constructed is the perpetual inventory method (PIM). For a given type of fixed asset, time series of gross fixed capital formation are deflated by means of the purchasers' price index of the same asset type, so that the quantities of assets are expressed in volume terms of a particular reference period. These time series in volume terms are then aggregated to yield a stock measure, where account is taken of retirement, efficiency losses or depreciation, depending on the nature of the stock measure constructed. The resulting stock measure is thus expressed in volume terms of the reference period chosen. This reference period may be the current period and stock measures valued in this way have often been labelled "current price capital stocks". However, this is not entirely accurate; as the description of the PIM showed, deflation is needed to arrive at these measures. Thus, they constitute a special case of a constant price valuation, namely valuation at the price vector of the current period.

~~18.174~~18.177 Even when the PIM is not applied, for example in the case of direct surveys of assets, the valuation of different vintages of a particular asset should not use book values that reflect historical prices. Consistent valuation requires that older vintages are valued by the prices of assets of specified ages at the point in time to which the survey refers.

~~18.175~~18.178 The next step is to aggregate the movements in capital stocks of individual asset types in volume terms. The use of linked or chain indices, as discussed earlier, is appropriate when building up a series that extends to the distant past since the current period price configuration will not remain representative.

~~18.176~~18.179 Further details on the PIM, on the different types of capital stocks and their measurement are provided in chapter 17 and in Measuring Capital.

8. Volume measures for stocks of non-produced natural resources and depletion

~~18.177~~18.180 For natural resources, estimates of the physical stocks of particular types of assets may be available, whereas observed market prices may not be available. As discussed in chapters 11 and 14, in this situation the net present value of future benefits may be used to estimate the values in monetary terms to be recorded in the SNA balance sheets. For a single, homogeneous natural resource, the volume estimates will be proportional to the physical stocks, but for aggregating different types of natural resources, index numbers are used to derive volume estimates.

~~18.178~~18.181 Depletion of non-produced natural resources reflects the decline in the quantity of a stock that is not offset by regeneration of the stock. In physical terms, depletion is the decrease in the quantity or value of the stock of a non-produced natural resource over an accounting period that is due to extraction of the natural resource by economic units occurring at a level greater than that of regeneration. In monetary terms, it corresponds with the decline in future income, due to extraction, that can be earned from a resource, the value of which is based on the physical flows of depletion using the price of the natural resource in situ. For measuring depletion in volume terms, the valuation of the physical flows of depletion uses the price of the natural resource in situ in effect in the reference period. If price indices need to be calculated, they can be derived as the ratio of the value expressed in current prices to the volume measure.

18.182 The change in volume of the stock during any period of any individual non-produced natural resource ~~asset~~ can be decomposed into the change in volume due to depletion, ~~the change in volume due to capital formation (in the case of biological resources),~~ and the change in volume due to other changes in assets (e.g., new additions to the stocks). The change in value of the stock in monetary terms is decomposed into depletion, other changes in assets, and revaluation. The depletion of non-produced natural resources in monetary terms is the change in physical stocks due to depletion multiplied by an average price in situ (i.e., the discounted unit resource rent) during the accounting period. The other changes in assets is the change in physical stocks due to other changes in assets times an average price in situ during the accounting period. The revaluation is the change in the price in situ multiplied by the average stock during the accounting period, though in practice it may be derived as a residual.

~~18.179~~18.183 For non-cultivated biological resources yielding once-only products, similar methodologies can be applied, albeit that the resource can also regenerate, thus giving rise to negative depletion. In the case of

Commented [ED8]: This is a new subsection largely drawn from Guidance Note WS.6

Commented [ED9]: The treatment of the change in volume of biological resources is under discussion. This paragraph will be edited to reflect the outcome of that decision.

cultivated natural resources yielding once-only products, the decrease in regenerative potential is recorded as depreciation, while an increase is recorded as fixed capital formation. For cultivated biological resources yielding repeat products, monetary values and volume estimates are typically compiled using the PIM methods as explained in the previous subsection, where the aggregation of volume estimates for individual asset types uses chain indices.

9. Components of value added

18.180 18.184 The price and volume measures considered up to this point relate mainly to flows of goods and services produced as outputs from processes of production. However, it is possible to decompose some other flows directly into their own price and volume components.

Compensation of employees Remuneration of employees

18.181 18.185 The quantity unit for remuneration of employees may be considered to be an hour's work of a given type and level of skill (see paragraphs 16.70 to 16.82 for more details). As with goods and services, different qualities of work must be recognized and quantity relatives calculated for each separate type of work. The price associated with each type of work is the compensation paid per hour which may vary considerably between different types of work. A volume measure of work done may be calculated as an average of the quantity relatives for different kinds of work weighted by the relative values of remuneration of employees in the previous year or a fixed base year. Alternatively, a "price" index may be calculated for work by calculating a weighted average of the proportionate changes in hourly rates of compensation for different types of work, again using relative remuneration of employees as weights. If a Laspeyres-type volume measure is calculated indirectly by deflating the remuneration of employees at current values by an index of hourly rates of compensation, the latter should be a Paasche-type index.

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Taxes and subsidies on products

18.182 18.186 Taxes on products are of two kinds, specific taxes linked to the volume of the product and ad valorem taxes levied on the value of the product. A measure of the tax volume of the former can be derived by applying the base year rate of the specific taxes to suitably deflated current value figures of the items bearing the specific tax and for the latter by applying the base year ad valorem rates to current values of items subject to ad valorem taxes deflated by appropriate prices. It is possible to derive a ratio of the tax data in current values and in volume terms but it is difficult to interpret this as a price index since it reflects changing tax rates and changing composition of the purchases of items subject to tax. The calculation for subsidies is carried out in an analogous manner.

18.183 18.187 There is more discussion on this in paragraphs 14.148 to 14.152.

Net operating surplus and net mixed income

18.184 18.188 When GDP is determined as the difference between output and intermediate consumption plus taxes less subsidies on production, gross value added is derived as an accounting residual. This is so in both current values and volume terms. In order for there to be an identity between different estimates of GDP in volume terms, it is not possible to give a price and volume dimension to gross value added. Rather the residual item is described as being "in real terms". If volume estimates of depreciation and depletion and remuneration of employees are available, net operating surplus and net mixed income can be derived but only in real terms and without a volume and price dimension. Thus it is not possible to derive an independent measure of GDP from the income approach since one item is always derived residually.

18.185 18.189 The limit to a set of integrated price and volume measures within the accounting framework of the SNA is effectively reached with net operating surplus. It is conceptually impossible to factor all the flows in the income accounts of the SNA, including current transfers, into their own price and volume components. However, any income flow can be deflated by a price index for a numeraire set of goods and services to measure the increase or decrease of the purchasing power of the income over the numeraire but this is quite different from decomposing a flow into its own price and volume components. A particular instance where this is common is in the calculation of the terms of trade effect on real income as described in section D.

10. Quarterly and annual estimates

~~18.186~~18.190 In principle, the same methods used to derive annual volume estimates should be used to derive quarterly volume estimates. Guidelines on data sources and methods for compiling price and volume quarterly estimates are given in chapters 3 and 8 of the Quarterly National Accounts Manual. The main considerations are those described in paragraphs 18.45 to 18.50. In practice, annual data are generally more comprehensive and accurate than quarterly data. Although there are important exceptions, such as exports and imports of goods, the overall situation is one of a much richer and more accurate, albeit less timely, set of annual data than quarterly data. For this reason, a sound approach is to compile balanced annual supply and use tables expressed in current values and in the prices of the previous year and to derive quarterly estimates that are consistent with them. This approach lends itself to the compilation of annually chained quarterly Laspeyres volume measures, although it can be adapted to the compilation of annually chained quarterly Fisher measures, too.

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11. Supply and use tables in volume terms

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~~18.187~~18.191 The rows of a use table show the way in which the total supply of a product is used for intermediate consumption, final consumption, capital formation and exports. This identity must hold in value terms. If the product in question is one where there is an unambiguous measure of quantity, the identity must also hold in volume terms. If the volume figures are derived by deflating the current values, the identity will only hold with certainty if each use category is deflated using a price index that is strictly appropriate to it.

~~18.188~~18.192 It is a good practice to compile supply and use tables in both current values and in volume terms at the same time so that the consistency of all the input data, including price indices, can be investigated together.

12. Summary recommendations

~~18.189~~18.193 The recommendations reached above on expressing national accounts in volume terms may be summarized as follows:

a. Volume estimates of transactions in goods and services are best compiled in a supply and use framework, preferably in conjunction with, and at the same time as, the current value estimates. This implies working at as detailed a level of products as resources permit.

b. In general, but not always, it is best to derive volume estimates by deflating the current value with an appropriate price index, rather than constructing the volume estimates directly. It is therefore very important to have a comprehensive suite of price indices available.

c. The price indices used as deflators should match the values being deflated as closely as possible in terms of scope, valuation and timing.

d. If it is not practical to derive estimates of value added in real terms from a supply and use framework and either the volume estimates of output and intermediate consumption are not robust or the latter are not available then satisfactory estimates can often be obtained using an indicator of output, at least in the short term. For quarterly data this is the preferred approach, albeit with the estimates benchmarked to annual data. An output indicator derived by deflation is generally preferred to one derived by quantity extrapolation.

e. Estimates of output and value added in volume and real terms should only be derived using inputs as a last resort since they do not reflect any productivity change.

f. The preferred measure of year-to-year movements of GDP volume is a Fisher volume index;

changes over longer periods being obtained by chaining, that is, by cumulating the year-to-year movements.

g. The preferred measure of year-to-year inflation for GDP and other aggregates is, therefore, a Fisher price index; price changes over long periods being obtained by chaining the year-to-year price movements, or implicitly by dividing the Fisher chain volume index into an index of the current value series.

h. Chain indices that use Laspeyres volume indices to measure year-to-year movements in the volume of GDP and the associated implicit Paasche price indices to measure year-to-year inflation provide acceptable alternatives to Fisher indices.

i. Chain indices for aggregates cannot be additively consistent with their components whichever formula is used, but this need not prevent time series of values being compiled by extrapolating base year values by the appropriate chain indices.

j. A sound approach to deriving quarterly current value and volume estimates is to benchmark them to annual estimates compiled in a supply and use framework. This approach lends itself to the construction of annually chained quarterly volume measures using either the Fisher or Laspeyres formulae.

D. Measures of real income for the total economy

1. The concept of real income

~~18.190~~18.194 Many flows in the SNA, such as cash transfers, do not have price and quantity dimensions of their own and cannot, therefore, be decomposed in the same way as flows related to goods and services. While such flows cannot be measured in volume terms they can nevertheless be measured "in real terms" by deflating their values with price indices in order to measure their real purchasing power over some selected basket of goods and services that serves as the numeraire.

~~18.191~~18.195 It is possible by use of a numeraire to deflate any income flow in the accounts and even a balancing item such as saving may be deflated by a price index in order to measure the purchasing power of the item in question over a designated numeraire set of goods and services. By comparing the deflated value of the income with the actual value of the income in the base year, it is possible to determine by how much the purchasing power of the income has increased or decreased. Income deflated in this way is generally described as "real income".

~~18.192~~18.196 Despite the terminology used, "real" incomes are artificial constructs that are dependent on two points of reference.

a. Real incomes are measured with reference to the price level in some selected reference year; they vary depending upon the choice of reference year.

b. Real incomes measure changes in purchasing power over some selected numeraire; they vary according to the choice of numeraire

~~18.193~~18.197 As there may often be no obvious or uncontroversial choice of numeraire there has always been some reluctance to show real incomes in national accounts on the grounds that the choice of numeraire should be left to the user of the statistics and not the compiler. However, when major changes in prices occur, it can be argued that compilers of statistics are under an obligation to present at least some measures of real income. Not all users of the accounts have the opportunity, inclination or expertise to calculate the real incomes which may be most suited to their needs. Moreover, there is a demand from many users for multipurpose measures of real income, at least at the level of the economy as a whole and the purpose of this section is to indicate how such measures may be compiled.

2. Trading gains and losses from changes in the terms of trade

~~18.194~~18.198 In a closed economy without exports or imports, GDP is equal to the sum of final consumption plus capital formation. This sum is described as domestic final expenditures. GDP is also a measure of the income generated in the economy by production. Although income cannot be expressed as the product of prices and volumes, if GDP can be deflated, then in effect this must also be a measure of income in real terms. However, with the inclusion of imports and exports, GDP is no longer identical to domestic final expenditure and deflation of GDP must allow for the deflation of imports and exports as well as of domestic final expenditures. Even if imports and exports are equal in current values, they usually have different prices so there is an impact on real income measures of import and export prices. This is generally done by considering the terms of trade and calculating what is known as the trading gains and losses from changes in the terms of trade.

~~18.195~~18.199 Further, the total real income that residents derive from domestic production depends also on the rate at which exports may be traded against imports from the rest of the world.

~~18.196~~18.200 ***The terms of trade are defined as the ratio of the price of exports to the price of imports***. If the prices of a country's exports rise faster (or fall more slowly) than the prices of its imports (that is, if its terms of trade improve) fewer exports are needed to pay for a given volume of imports so that at a given level of domestic production goods and services can be reallocated from exports to consumption or capital formation. Thus, an improvement in the terms of trade makes it possible for an increased volume of goods and services to be purchased by residents out of the incomes generated by a given level of domestic production.

~~18.197~~18.201 ***Real gross domestic income (real GDI) measures the purchasing power of the total incomes generated by domestic production.*** It is a concept that exists in real terms only. When the terms of trade change there may be a significant divergence between the movements of GDP in volume terms and real GDI. The difference between the change in GDP in volume terms and real GDI is generally described as the "trading gain" (or loss) or, to turn this round, ***the trading gain or loss from changes in the terms of trade is the difference between real GDI and GDP in volume terms***. The differences between movements in GDP in volume terms and real GDI are not always small. If imports and exports are large relative to GDP and if the commodity composition of the goods and services that make up imports and exports is very different, the scope for potential trading gains and losses may be large. This may happen, for example, when the exports of a country consist mainly of a small number of primary products, such as cocoa, sugar or oil, while its imports consist mainly of manufactured products. Trading gains or losses, T, are usually measured by the following expression:

$$T = \frac{X-M}{P} - \left\{\frac{X}{P_x} - \frac{M}{P_m}\right\} \qquad (19)$$

where

X = exports at current values

M = imports at current values

P_x = the price index for exports

P_m = the price index for imports

P = a price index based on some selected numeraire.

P_x, P_m and P all equal 1 in the base year. The term in brackets measures the trade balance calculated at the export and import prices of the reference year whereas the first term measures the actual current trade balance deflated by the numeraire price index. It is perfectly possible for one to have a different sign from the other.

~~18.198~~18.202 In addition to changes in the terms of trade, another factor that may affect real income measures is changes in the relative price of traded goods and services (measured as the average of import prices and export prices) with respect to the price of nontraded goods and services. This factor is known as the real exchange rate effect. The effects of changes in the real exchange rate depend on the position of the trade

Commented [ED11]: This new paragraph acknowledges a point raised in an article in Review of Income and Wealth (2022) that real income measures are affect by real exchange rate effects as well as terms of trade effects.

account. For given terms of trade, if imports exceed exports, then a depreciation of the domestic currency (that is, an increase in the price of traded goods and services relative to nontraded goods and services) results in a decline in real income. On the other hand, if exports exceed imports, then these effects go in the opposite direction.

~~18.199~~18.203 There is one important choice to be made in the measurement of trading gains or losses, the selection of the price index P with which to deflate the current trade balance. There is a large but inconclusive literature on this topic, but one point on which there is general agreement is that the choice of P can sometimes make a substantial difference to the results. Thus, the measurement of real GDI can sometimes be sensitive to the choice of P and this has prevented a consensus being reached on this issue.

~~18.200~~18.204 It is not necessary to try to summarize here all the various arguments in favour of one deflator rather than another, but it is useful to indicate the main alternatives that have been advocated for P. They can be grouped into three classes, as follows.

a. One possibility is to deflate the current balance, X-M, either by the import price index (which has been strongly advocated) or by the export price index, with some authorities arguing that the choice between P_m and P_x should depend on whether the current trade balance is negative or positive.

b. The second possibility is to deflate the current balance by an average of P_m and P_x various different kinds of averages have been suggested, simple arithmetic or harmonic averages, or more complex trade weighted averages.

c. The third possibility is to deflate the current balance by some general price index not derived from foreign trade; for example, the price index for gross domestic final expenditure, or the consumer price index. An advantage of a general price index not derived from foreign trade (such as the price index for gross domestic final expenditure) is that it incorporates real exchange rate gains and losses in addition to terms-of-trade gains and losses.

~~18.201~~18.205 The failure to agree on a single deflator reflects the fact that no one deflator is optimal in all circumstances. The choice of deflator may depend on factors such as whether the current balance of trade is in surplus or deficit, the size of imports and exports in relation to GDP, etc. On the other hand, there is general agreement that it is highly desirable and, for some countries vitally important, to calculate the trading gains and losses resulting from changes in the terms of trade. In order to resolve this deadlock it is recommended to proceed as follows:

a. Trading gains or losses, as defined above, should be treated as an integral part of the SNA;

b. The choice of appropriate deflator for the current trade balances should be left to the statistical authorities in a country, taking account of the particular circumstances of that country;

c. If the statistical authorities within a country are uncertain what is the most appropriate general deflator P to be used, some average of the import and export price indices should be used, the simplest and most transparent average being an unweighted arithmetic average of the import and export price indices. (This is referred to in the specialist literature on the subject as the Geary method.)

~~18.202~~18.206 These proposals are intended to ensure that the failure to agree on a common deflator does not prevent aggregate real income measures from being calculated. Some measure of the trading gain should always be calculated even if the same type of deflator is not employed by all countries. When there is uncertainty about the choice of deflator, an average of the import and the export price indices is likely to be suitable.

3. The interrelationship between volume measures of GDP and real income aggregates

~~18.203~~18.207 The usual way to calculate real income figures is to start from real GDI and then follow the normal sequence of income aggregates, but with every intervening adjustment deflated to real terms. This is illustrated as follows:

a. Gross domestic product in volume terms;

plus the trading gain or loss resulting from changes in the terms of trade;

b. *equals* real gross domestic income;

plus real earned incomes receivable from abroad;

minus real earned incomes payable abroad;

c. *equals* real gross national income;

plus real current transfers receivable from abroad;

minus real current transfers payable abroad;

d. *equals* real gross national disposable income;

minus depreciation and depletion in volume terms;

e. *equals* real net national disposable income.

~~18.204~~18.208 The transition from (a) to (b) is the trading gain from changes in the terms of trade explained immediately above. The steps needed in order to move from (b) to (d) above involve the deflation of flows between resident and non- resident institutional units, namely, earned incomes and current transfers receivable from abroad and payable to abroad. There may be no automatic choice of price deflator, but it is recommended that the purchasing power of these flows should be expressed in terms of a broadly based numeraire, specifically the set of goods and services that make up gross domestic final expenditure. This price index should, of course, be defined consistently with the volume and price indices for GDP.

~~18.205~~18.209 Each step in the process should first be calculated for adjacent years in additive volume terms and longer series derived as chain indices.

~~18.206~~18.210 A possible alternative approach is to move from GDP in volume terms to net domestic final expenditure in volume terms and then make a single adjustment for the impact on purchasing power of the current external balance using the deflator for net final domestic expenditure to reduce the current external balance to real terms. The advantage of this alternative is a single numeraire, the set of goods and services making up net domestic final expenditures being used throughout. It may be easier, therefore, to grasp the significance of real net national disposable income as this deflator is explicit.

~~18.207~~18.211 However, the alternative framework measures the trading gain or loss by using the deflator for net domestic final expenditures as the general deflator P, for the trading gain or loss from changes in the terms of trade whereas it can be argued that P ought always to be based on flows which enter into foreign trade. On balance, therefore, the original framework presented above is to be preferred.

E. Volume and price measures for particular products or industries

~~18.208~~18.212 For most products and industries, the methods discussed in Section C of this chapter can be used to derive volume and price measures that are appropriate for national accounts. There are, however, several products that have somewhat unusual characteristics for which more specific guidance may be helpful. For a few particular products, this section provides a brief discussion of some of the challenges that arise for these products and explains some methods that some countries use to address these challenges. For further guidance on volume and price measurement for particular products or industries, please refer to handbooks on this topic, such as Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition and the other references cited in this section.

1. Agricultural output

Commented [ED12]: New section - Issue X.22 - Recommends adding new section on measuring prices, volumes for specific products.

Commented [ED13]: New subsection based on section 5.3.1 of Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition.

~~18.209~~18.213 As discussed in paragraphs 7.148–7.150, the output of agriculture, forestry, and fishing is complicated by the fact that the process of production may extend over many months, or even years. For many crops the growing season will span three quarters of the year, with the harvest taking place in the third quarter, and preparation of the fields taking place in the last quarter of the preceding year.

~~18.210~~18.214 To derive volume measures of crop output, it is recommended that for each type of crop, the compilers distribute forecasts of the value of harvest output across the quarters in proportion to the input costs in each quarter. An alternative method is to assume that output in those quarters with no production of finished goods is equivalent to input costs. The alternative method avoids the necessity of deriving forecasts of the value of harvest output but could distort the quarterly pattern of output by assuming that the net operating surplus or net mixed income is entirely attributable to the quarter when the crop is harvested.

~~18.211~~18.215 When calculating the volume of quarterly agricultural output, the main difficulty is to decide which price index to use. Theoretically, the price to be applied should be the price prevailing during the period of production, but in practice the prices prevailing during quarters out of the harvest season might be rather unsuitable due to the scarcity of the crop outside of the harvest season. In such circumstances, it may be better to substitute prices related to the basic price forecast for final harvest output in place of the price prevailing in other quarters. If the alternative method discussed in the previous paragraph is used, it is important that one should continue to use a forecast of the product price as a deflator, since deflation by a price index for inputs would only generate the volume of inputs.

2. Large construction projects

Commented [ED14]: New subsection based on sections 2.5 and 4.6 of Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition.

~~18.212~~18.216 For construction, compilers are encouraged to avoid input cost methods and endeavor to develop output price indices that can be used for deflation. Compiling output price indices can be challenging, though, because each construction project tends to be unique in certain respects, so repricing identical models each period is challenging. For smaller projects, such as houses, small apartment buildings and small office buildings, it may be possible to collect information from construction enterprises on prices over time for a standardized “model” product, such as a typical family house with specified characteristics. For larger projects, such as large factories, highways, and reservoirs, the model pricing approach is not likely to be feasible and other methods must be considered.

~~18.213~~18.217 Specification pricing may be another possibility if it is possible to break down the attributes of the construction project into identifiable elements. This approach requires that the elements should be separately identifiable, their qualities and impact on the performance of the structure should be quantifiable, and prices for each element should be available in different periods. This approach has the advantage that it allows more flexibility than a standardized model, but in practice it may be difficult to identify the key elements of a project and to collect prices for each of those elements. A related method is the hedonic method, which also requires identifying characteristics that are thought to determine the price of the project, but uses regression methods rather than direct data collection to determine the price for each element.

~~18.214~~18.218 Although generally not the preferred method, the use of input prices may be acceptable when projects are so unique that it is not possible to use either specification pricing or the hedonic method to derive a price index.

3. Digital goods and services

Commented [ED15]: New section per DZ.1, DZ.3, DZ.8. These topics are covered in detail in chapter 22.

~~18.215~~18.219 As discussed in chapter 22, digital products include assets that exist only in digital form and services that are supplied over a computer network. Examples of digital assets include crypto assets, data and software. Examples of digital services include wholesale and retail e-commerce distribution services, priced and free services of online platforms, audio and video streaming, and digital financial and payment services such as mobile money services. Their production and consumption are enabled by ICT equipment, software, and data and databases along with ICT consumer durable goods, and mobile and fixed line digital communication services. As an example, this section considers the volume and price measurement of software and databases.

~~18.216~~18.220 Volume and price measurement challenges are common for products affected by digitalization because innovation leads to rapid changes in the characteristics and sources of supply of digital products. New digital products regularly disrupt existing ones, new models or service contracts frequently embody quality improvements, digital intellectual property products and services with no physical units of measurement are growing in importance, and free products often appear or cease to be free.

~~18.217~~18.221 To deal with these rapid changes, the samples used to calculate the price indexes for digital products subject to frequent quality improvements need to be regularly refreshed to keep them representative of current consumption patterns. In addition, the appearance of new models and the exit of obsolete models must be handled in a way that reflects the value of the quality changes. In some cases, the prices of new characteristics may be observable from the price differences associated with various options that the seller offers to consumers. Another way of handling these quality changes is through explicit estimation of quality changes through hedonic methods.

~~18.218~~18.222 These general issues and specific examples of volume and price measurement of digital products, including cloud computing and free products, are discussed in detail in section E of chapter 22. The example of software and databases is considered here.

~~18.219~~18.223 When deriving volume estimates of the capital formation of software and databases it is advisable to decompose software into three components: packaged (or off-the- shelf), custom-made and own account and to deflate them and databases separately. There are several reasons for doing this.

a. The three components of software and databases vary in the extent to which price data are available to compile price indices.

b. It is likely that their prices and volumes grow at different rates, particularly between packaged software, the other two software components and databases.

c. Despite the previous point, price indices for packaged software may be used to construct price indices for the other two software components if more appropriate price indices are unavailable.

d. Volume estimates of the items are useful indicators in their own right.

~~18.220~~18.224 Packaged software is purchased on a very large scale, generally via licences-to-use and there is an abundance of price data available. The challenge is to construct price indices free of the effects of changing specifications and any other aspects of quality change.

~~18.221~~18.225 Custom-made software is also sold on the market, but each custom-made software product is a one-off, which presents an obvious problem for compiling price indices. Although each custom-made product is different, different products may share common components, or a strategy used to develop one product may be able to be used for another. This not only suggests a possible way of compiling a price index, but also suggests means by which productivity gains could be made that would put downward pressure on prices. In sections B and E the use of model pricing is outlined for measuring price changes of custom-made buildings. A similar approach may be applied to custom-made software, or hedonic methods might be applied.

~~18.222~~18.226 Methods for compiling price indices for heterogeneous groups of products and products whose specifications are changing rapidly are described in the *Handbook on Hedonic Indices and Quality Adjustments* and in *Producer Price Index Manual: Theory and Practice, (*the International Labour Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, Economic Commission for Europe and the World Bank, 2004).

~~18.223~~18.227 A substantial proportion of software in gross fixed capital formation is undertaken on own account. Hence, it is not possible to derive a true output price index for such software. It is then a matter of choosing between a pseudo output price index and an input price index, obtained by weighting together price indices of the inputs. As already noted, input volume estimates used as a proxy for output do not reflect any productivity growth and so this is not recommended. In the absence of a better alternative, the most obvious option is to use the price index for custom- made software.

~~18.224~~18.228 Databases are generally heterogeneous products with a small market since most databases are made for in-house purposes. Volume and price measures for data are discussed in section E of chapter 22. For

Formatted: Font: (Default) +Headings CS (Times New Roman), 10 pt, Font color: Auto, Complex Script Font: +Headings CS (Times New Roman), 10 pt, Don't snap to grid, Not Highlight own-account software, it is difficult, if not impossible, to develop a true output price index and once again the choice is between a pseudo output price index and an input price index though a pseudo output index may be difficult to envisage.

4. Passenger transport services and price discrimination

~~18.225~~18.229 It is not unusual for two airline passengers sitting in adjacent seats to pay very different prices for the same transport services. In some cases, there may be differences in the bundle of services provided with the ticket (for example, one ticket may provide for a refund if the ticket needs to be cancelled), but in other cases there are no meaningful differences in products characteristics. Rather, the difference in price may be explained by price discrimination.

~~18.226~~18.230 As explained in paragraph 18.71, price discrimination occurs when groups of purchasers who differ in their willingness to pay for a product are charged different prices by a seller who is able to segment the market and charge different prices based on those differences in willingness to pay. Price discrimination occurs more often in the provision of services than goods because goods can be retraded (and are thus subject to arbitrage), whereas services generally are not retraded. Other examples of services for which price discrimination may be common include electricity distribution, financial services, education and health.

~~18.227~~18.231 With respect to price and volume measurement, there are two key issues. The first is whether the prices truly are homogenous, or whether there are subtle differences in quality between items that appear to be identical (except for a difference in price). For example, an airline can charge more for economy class seats that offer more leg room than other economy class seats, and that difference should be treated as a difference in quality rather than price. It could also charge a different price for a seat purchased immediately before a flight than one purchased several weeks in advance. The compiler of the price index should try to hold such subtle differences in characteristics constant when specifying the description of the ticket that is being priced. But when price discrimination leads to different prices being charged for two products with no differences in quality, the differences should be attributed to price rather than volume.

~~18.228~~18.232 One way to ensure that differences in price due to price discrimination are not mixed in with volume would be to divide the customers into homogeneous groups. For example, on an air flight travelling on a specific route, the passengers may be grouped into first class, premium economy, and economy class. For each group, the volume is measured by the number of passengers taking the trip and the price is the average price paid by passengers within each group. This decomposition could then be applied to a representative sample of flights travelling on various routes to obtain price and volume indices for air transport services.

5. Output of the central bank

~~18.229~~18.233 As explained in chapter 7, central banks provide a variety of financial services, including monetary policy services, services related to promoting financial stability, services related to managing international reserves and payment systems and services related to acting as banker to government. In general, these services are provided for free, or at prices which are not economically significant, for the benefit of society as a whole. These services of central banks are considered non-market output provided to the society as a whole (i.e., collective services), and total output is to be valued at the sum of costs. Unless an indicator of productivity is available (which is unlikely because the services of central banks generally cannot be observed), the most appropriate volume measure is the deflation of the inputs.

6. Implicit financial services on loans and deposits

~~18.230~~18.234 As described in 7.179–7.188, implicit financial services on loans and deposits are implicit charges paid by depositors or borrowers to a financial institution such as a bank for the services associated with intermediation. These charges are indirect because they are derived from the interest rates associated with the loans and deposits in relation to a reference rate of interest and are not explicit fees charged for services. Thus, traditional methods of deflation are not available for these services and alternative methods must be

Commented [ED16]: Discussion of price discrimination is based on section 2.1.4 of Eurostat, *Handbook on prices and volume measures in national accounts* (2016 edition).

Commented [ED17]: New subsection reflecting issue note X.3 and Issues note on action point A.9 (AEG meeting July 10–13, 2023).

Commented [ED18]: New subsection based on issue note X.10; also draws on Eurostat, *Handbook on prices and volume measures in national accounts* (2016 edition).

used.

~~18.231~~18.235 Two main approaches have been used for volume and price measures of implicit financial services on loans and deposits. The *deflated sto~~i~~cks approach* involves deflating the stocks of loans and deposits using a general price index and applying the previous year's (or base year) reference rates to arrive at borrower implicit financial services and depositor implicit financial services in volume terms. The *output indicators approach* focuses on indicators of specific services that ~~that~~ the financial institution provides to borrowers and depositors, such as debit and credit card transactions, automatic teller machine transactions, and cheque transactions, which serve as proxies for the volume of financial services provided by the financial institution.

~~18.232~~18.236 The output indicators approach ~~is attempting~~attempts to decompose the services provided by a financial institution such as a bank into the distinct activities that it undertakes on behalf of its customers. Advantages of this approach are that the indicators may directly reflect the provision of services that customers value and provide insight into the activities undertaken by the bank. In practice, this approach has also encountered several obstacles and disadvantages. Indicators may not be available for all the specific services provided by banks, and the omission of services that are poorly measured could bias the rate of growth of the overall volume measure. The approach requires that the various output indicators should be weighted, and because there is no observable price or revenue for these services, deriving appropriate weights can be a difficult and complex task. The data burden of compiling the output indicators and their associated weights is likely to be high, and the indicators and weights may tend to become outdated in the face of technological changes and increased digitalization of financial services. In general, it may also be difficult to maintain such a measure and keep the weighting and list of indicators current in the face of rapid changes in the ways that financial services are provided and paid for.

~~18.233~~18.237 The more commonly used method is the deflated stocks approach, in which the stocks of deposits and loans are deflated using a general price index. Rather than decomposing the specific activities undertaken by banks, the deflated stocks approach takes the broader view that intermediation services are ultimately related to allowing the borrower or depositor to engage in deposit and loan transactions, either in the current period or in a future period. The stock of loans or deposits is related to the capacity to engage in transactions, and those transactions are best measured in volume terms using a general price index. In applying the deflated stocks approach, compilers should apply a general price index appropriate for the country and apply the previous year's reference rates to arrive at borrower implicit financial services and depositor implicit financial services in volume terms. Furthermore, because different kinds of loans or deposits have different margins between their interest rate and the reference rate, each type of loan or deposit should be deflated separately, and then the various types of loans and deposits should be aggregated using a price index formula (such as the Paasche price index or Fisher price index that have been discussed in this chapter). The general price index used for deflation should, if possible, exclude implicit financial services on both conceptual grounds (the transactions supported by loans and deposits do not include implicit financial services) and practical grounds (the inclusion of these services would create a circularity in the calculation of the overall index, which could be problematic). Stocks associated with exports of implicit financial services should be deflated using a general domestic price index, while for imports the appropriate country price indices should be used (along with exchange rate adjustments if the stocks are held in a different currency of that of the domestic economy).

~~18.234~~18.238 In view of its relative simplicity, the deflated stocks approach is generally preferred for calculating volume measures of implicit financial services on loans and deposits. Countries should select a general price index for deflation that is accurate and appropriate for the types of transactions that are most often supported by loans and deposits in the country. The output indicator approach could also be used to calculate volume measures of implicit financial services.

7. Services of owner-occupied dwellings

~~18.235~~18.239 As discussed in 7.126–7.128, households that own the dwelling they occupy are treated as owners of unincorporated enterprises that produce housing services consumed by those same households. When well-organized markets for rental housing exist, the output of own-account housing services can be valued using the prices of the same kinds of services sold on the market in line with the general valuation rules

Commented [ED19]: New subsection based on section 4.12.2 of Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition and paragraphs 11.87 to 11.102 of *Consumer Price Index Manual*, 2020 edition adopted for goods or services produced on own account. In other words, the output of the housing service produced by owner occupiers is valued at the estimated rental that a tenant would pay for the same accommodation, taking into account factors such as location, neighbourhood amenities, etc., as well as the size and quality of the dwelling itself. Due to the absence of an explicit price for these services, indirect approaches must be used to derive volume and price measures.

~~18.236~~18.240 The stratification approach is generally recommended ~~by Eurostat's *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition~~. In a benchmark year (or annually if the necessary data and resources are available), compilers match actual rents paid by those renting in particular strata to similar dwellings used by owner occupants in equivalent strata to derive their rental equivalence value. The benchmark estimate makes use of detailed data on the housing stock broken down between owner-occupied and rented property and by the attributes of these properties that influence the rent, such as floor area, number of rooms, number of bathrooms, etc. This method is known as the 'stratification method' because it is based on the stratification of dwelling attributes and rent. The approach can be seen as providing price and quantity data at a detailed level for the estimation of output for a particular year.

~~18.237~~18.241 Estimates for years other than the benchmark year are estimated by projecting forward the housing stock and rents with indicators that reflect the development of these variables over time. The indicators are chosen to reflect adequately the three components of change: the change in price, change in the quantity of the stock, and change in the quality of the stock.

~~18.238~~18.242 If the stratification method cannot be used, then price indices or volume indicators need to be constructed. The *Consumer Price Index Manual,* 2020 edition, paragraphs 11.87 to 11.102, discusses ways to estimate a price index for the services of owner-occupied dwellings that are broadly consistent with the concepts used in the SNA. The index can be calculated, for example, from a sample of rented housing units that are weighted to reflect the current composition of owner-occupied units. This approach requires that a country have a transparent rental market and reliable information on rents by type of accommodation, location and other rent-determining factors. In general, if the volume of the services of owner-occupied dwellings is to be calculated by deflation, care should be taken to ensure that the concepts and coverage in the deflator match the concepts and coverage used to measure the value of those services in the accounts.

~~18.239~~18.243 Whether the stratification method or the price index method is used, subsidized and controlled prices should not be used in calculating the owners' equivalent rental series, though they should be used in calculating the prices of rented units.

~~18.240~~18.244 Another consideration in deriving price and volume measures of the services of owner-occupied dwellings is the growing importance of owners subletting part or all of a dwelling to tourists or travelers. In particular, new digital marketplaces for subletting have made it easier to sublet a dwelling and have led to substantial growth in this activity. Traditional housing surveys may have considered this type of subletting to be too unimportant to measure, which may lead to omission or undercounting of these transactions. For the volume measure of the services of owner-occupied dwellings, if the value of the services is based on the rental equivalence of similar rented dwelling that is not sublet, the value of the subletting needs to be deducted from the rental equivalence of the owner-occupant's unit to avoid double counting the services of the unit (as explained in paragraphs 7.127 to 7.128).

8. Education services

~~18.241~~18.245 In section C.5 of this chapter, the general principles for measuring volumes and prices of non-market output are explained. Here an example is provided of how the volume of output of non-market education services might be estimated in practice. The handbooks, Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition and OECD, *Towards Measuring the Volume Output of Education and Health Services: A Handbook,* 2009, provide more detailed guidance on these services.

~~18.242~~18.246 For primary and secondary education, educational output can be measured based on the amount of teaching received by the students for each type of education. This can be measured as the number of student-hours, or if this measure is not available, the simple number of students or pupils can be used provided the hours of instruction remain broadly stable over time. For higher education, and especially for specialized schools, such as medical schools, there may be other aspects of training that are more resource intensive

Commented [ED20]: New subsection based on Eurostat, Handbook on Prices and Volume Measures, and OECD, Towards Measuring the Volume Output of Education and Health Services.

and would not be captured by the hours of instruction. For those types of education, additional stratification and other indicators may need to be added.

9. Health services

Commented [ED21]: New subsection based on Eurostat, Handbook on Prices and Volume Measures, and OECD, Towards Measuring the Volume Output of Education and Health Services.

~~18.243~~18.247 As for education services, we refer to section C.5 of this chapter for an explanation of the general principles for measuring volumes and prices of non-market output. Here an example is provided of how the volume of output of non-market health services might be estimated in practice. The handbooks, Eurostat, *Handbook on Prices and Volume Measures in National Accounts,* 2016 edition and OECD, *Towards Measuring the Volume Output of Education and Health Services: A Handbook,* 2009, provide more detailed guidance on these services.

~~18.244~~18.248 Health services are characterized by substantial heterogeneity in the conditions that are being treated and in the types of treatment that are appropriate for each condition. Because the treatment of a condition may involve a bundle of services provided over a period of time, including medical services, laboratory services, and in some cases hospital services, it may not be possible in practice to capture the full treatment of the condition. For hospital services, data may be classified based on the international classification of diseases (ICD) or on diagnosis related groups (DRG), which are systems used to classify medical conditions into relatively homogeneous categories.

~~18.245~~18.249 For market output of hospital services, a PPI or CPI that is representative and controls for quality may provide a good deflator. For non-market output of hospital services, volume estimates may be calculated on the basis of direct output measures such as number of discharges by ICD or DRG category weighted by appropriate cost or revenue weights. These methods should be applied at a detailed level to avoid mixing different types of treatments. The most used alternatives are either a unit cost index or a direct volume index, depending on data availability.

F. Estimating labour and multifactor productivity

Commented [ED22]: New section that mostly draws from chapter 19, section E of the *2008 SNA,* along with some material from pp. 14-18 of OECD, *Measuring Productivity.*

1. Labour productivity

~~18.246~~18.250 Volumes of output per hour worked (or per person employed) are described as measures of labour productivity. However, this is a somewhat unsophisticated measure because changes in this measure can reflect a number of factors other than just the number of hours of labour employed. In particular, increases in the amount of capital used can affect this ratio as can changes in the composition of the labour input over time. Volume measures of labour input are discussed in detail in section D of chapter 16, and the topics of labour, capital and multifactor productivity are discussed in detail in *Measuring Productivity*.

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~~18.247~~18.251 Labour productivity shows the time profile of how productively labour is used to generate output in volume terms. Changes in labour productivity reflect the joint influence of changes in capital, intermediate inputs, as well as technical, organizational and efficiency change within and between enterprises, the influence of economies of scale, varying degrees of capacity utilization and measurement errors.

~~18.248~~18.252 Neither the number of employed persons nor full-time equivalent numbers on labour input are ideal measures for use in productivity studies. The series for total hours actually worked is preferred by many because it is a reasonable compromise between these cruder measures and data-intensive measures that adjust for differences in the qualifications, skill levels and composition of labour.

~~18.249~~18.253 Using total hours actually worked as the input measure for calculating labour productivity changes over time implicitly assumes that each hour worked is of the same quality. As discussed in paragraphs 16.95 to 16.97, it is possible to produce a quality-adjusted measure of the labour inputs that takes account of changes in the mix of workers over time by weighting together indicators of quality for workers with different levels of skill or education.

~~18.250~~18.254 Whichever labour measure is used in calculating productivity, it is very important to ensure that the coverage of the labour data is consistent with that of the national accounts. In other words, the labour inputs must be estimated within the same production boundary and using the same criteria for residence that are used in the national accounts. Typically, the topics that cause most difficulty are residence (particularly with border workers), defence force and diplomatic personnel (who are commonly not covered by the labour force surveys used to provide the basic data) and obtaining details of unpaid hours (for example, unpaid overtime) or of some self employment (for example, contributing family workers).

~~18.251~~18.255 Analysts are often interested in measuring productivity on an industry basis as well as for the economy as a whole. Calculating industry employment and working time by industry adds an additional degree of difficulty to the estimation process. Among other advantages, using hours worked overcomes the problems involved in measuring employment by industry when a worker has two or more jobs, not in the same industry.

~~18.252~~18.256 Labour productivity, including industry productivity, and multifactor productivity (see below) are all valid measures of an economy's performance. From a practical viewpoint, it is important to ensure that the employment and hours worked underlying these sets of estimates are consistent with each other as well as with output measures when calculating the productivity estimates.

Data consistency

~~18.253~~18.257 Examining the relative productivity performance of different industries is of interest to many analysts. In practice, the labour input estimates for the whole economy can be estimated either "bottom up" or "top down". In the former case, the totals for the economy as a whole will be completely consistent with the industry estimates because they are summed to derive the total labour estimates. However, in the case of a top-down approach, a range of different data sources may be used to obtain the disaggregation by industry. In such cases, it is important to ensure that the sum of the industry estimates is consistent with the national totals.

~~18.254~~18.258 Classifying labour input by industry is not always straightforward. The main issue is to ensure that the employment estimates for each industry are as consistent as possible with the national accounts values and volumes so that the productivity estimates are reliable. One particular problem that arises is where staff are recruited via an external recruitment agency. Maintaining consistency with the industry output means that employment should be classified to the industry of the establishment that legally employs the workers. In practice, this will be the establishment that pays the employee's wages and any associated social contributions, which will usually be the employment agency and so the employees will be classified to industry class 7491 *Labour recruitment and provision of personnel.* The output of this industry includes the revenue derived from the activity of hiring out staff to those establishments that need the staff; generally, those establishments will be in other industries. The establishments using these staff pay the employment agency and then the employment agency pays the staff so the payments by the "using" establishments will be recorded as part of intermediate input for the using industry.

~~18.255~~18.259 Ideally, for productivity purposes both the output attributable to these staff and the hours they work would be recorded in the industry in which they are actually working rather than in the industry "Labour recruitment and provision of personnel". However, in practice, it is unlikely that the data can be collected to enable the output and hours worked to be classified this way. It may be useful for some purposes for the staff hired out by employment agencies to be allocated to the industries that actually use the staff. If such an allocation of labour input is performed, similar adjustments to intermediate consumption and value added of the relevant industries would also be required. However, any such allocation should be presented in a supplementary table and not in the main accounts.

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2. Capital productivity

~~18.256~~18.260 Measures of capital productivity, calculated by dividing the volume of output (or volume of value added) by a volume index of capital services provided, suffer from similar drawbacks to labour productivity since they do not capture the effects of the amount of labour employed and the efficiency and composition of the capital inputs.

~~18.257~~18.261 The capital productivity index shows the time profile of how productively capital is used to generate value added or output. Capital productivity reflects the joint influence of labour, intermediate inputs, technical change, efficiency change, economies of scale, capacity utilization and measurement errors. Like labour productivity, capital productivity measures can be based on output volume or value-added volume.

~~18.258~~18.262 The index of capital services is related to the capital services for the total economy, as shown in chapter 17, table 17.11. Volumes of capital services for the individual asset types and industries need to be aggregated using a Laspeyres or Fisher index to form an index of capital services for the total economy.

3. Multifactor productivity

~~18.259~~18.263 A measure that takes account of the contributions of both labour and capital to growth in output is multifactor productivity (MFP), which is sometimes referred to as total factor productivity (TFP). The advantage of using MFP as the measure of productivity is that it includes effects not included in the labour and capital inputs. This topic is discussed further in chapter 20 and in *Measuring Capital.*

~~18.260~~18.264 Capital-labour MFP is calculated as a volume index of value added divided by a volume index of combined labour and capital input. Capital-labour MFP indices show the time profile of how productively combined labour and capital inputs are used to generate value added. Conceptually, capital-labour productivity is not, in general, an accurate measure of technical change. It is, however, an indicator of an industry's capacity to contribute to economy-wide growth of income per unit of input. In practice, the measure reflects the combined effects of disembodied technical change, economies of scale, efficiency change, variations in capacity utilization and measurement errors.

~~18.261~~18.265 The productivity model can be extended to include other factors such as the energy and materials used in production. The abbreviation "KLEMS", standing for capital (K), labour (L), energy (E), materials (M) and purchased services (S), is often used for this extended productivity model. This can be extended to producing productivity estimates at the most detailed level of the supply and use tables. KLEMS MFP is calculated as a volume index of output divided by a volume index of combined inputs, including different types of labour, capital, energy, materials and services, each weighted with its share in total output. KLEMS MFP shows the time profile of how productively combined inputs are used to generate output. Conceptually, the KLEMS productivity measure captures disembodied technical change. In practice, it also reflects efficiency change, economies of scale, variations in capacity utilization and measurement errors.

~~18.262~~18.266 An example of such work can be found in the EU-KLEMS project, which can be found on the project site https://www.rug.nl/ggdc/productivity/eu-klems/.

G. International price and volume comparisons

1. Introduction

~~18.263~~18.267 Users want to compare GDP and its components not only over time for a given country or countries in analyzing economic growth, for example, but also across countries for a given time period in analyzing relative economic size. A commonly used method of making such comparisons is to adjust national accounts values to a common currency using exchange rates, which has the advantage that the data are readily available and completely up to date. This is adequate if users need a ranking of a country's relative spending power on the world market. However, it is not adequate for comparisons of productivity and standards of living because it does not adjust for the differences in price levels between countries and thus does not give a measure of countries' relative sizes in the volume of goods and services they produce.

~~18.264~~18.268 Purchasing power parities (PPPs) are used in producing a reliable set of estimates of the levels of activity between countries, expressed in a common currency. *A purchasing power parity (PPP) is defined as the number of units of B's currency that are needed in B to purchase the same quantity of individual good or service as one unit of A's currency will purchase in A.* Typically, a PPP for a country is expressed in terms of the currency of a base country, with the US dollar commonly being used. PPPs are thus weighted averages of the relative prices, quoted in national currency, of comparable items between countries. Used as deflators, they enable cross-country comparisons of GDP and its expenditure components.

~~18.265~~18.269 This section first examines the index number issues in aggregate comparisons of prices and volumes across countries. The ICP produces internationally comparable economic aggregates in volume terms as well as PPPs and price level indices (PLIs). Established in 1968, the ICP has grown to cover all regions of the world in combination with the OECD/Eurostat PPP program.

~~18.266~~18.270 Compiling PPP-based data is a costly and time-consuming exercise, so it is not possible to make such comparisons as a matter of course. Worldwide coordination is required to collect the data and compile the PPP-based estimates. However, national accountants in participating countries need to understand the basic principles of the comparison and the practical demands that are made on them for data to compile PPP indices and thus GDP volume comparisons. This material is the subject of the last part of this section.

2. Index number issues

~~18.267~~18.271 The theory of index numbers developed in a time series context cannot be applied mechanically to international comparisons simply by replacing the term "period" by the term "country." International comparisons differ in a number of respects.

a. Time series are ordered by the date of the observation, but countries have no such a priori ordering. In consequence there is no predetermined way to order countries when compiling chain indices.

b. For international price comparisons different price collectors will be reporting on the prices of the items in different countries. There thus is a need for flexible but detailed structured product descriptions (SPDs) for each item so that only the prices of like items are compared, either by comparing the prices of exactly the same item specification drawn from the SPD in both countries, or by adjusting the prices of different specifications drawn from the SPD for quality differences.

c. International comparisons are conducted on a less regular basis, in part because they present a large scale coordination challenge, involving the statistical offices of all participating countries as well as international organizations.

~~18.268~~18.272 At the heart of the PPPs are price comparisons of identical or closely similar product specifications. The 2005 ICP round used SPDs to define these specifications and to ensure the quality of the detailed price comparisons. For each item there is a specification describing the technical characteristics of the item in detail so a price collector can precisely identify it in the local market. Besides the technical characteristics, the specification also includes other variables that need to be considered when pricing the item, such as the terms of sales, accessories and transportation and installation costs. The database formed from these structured descriptions and the prices collected for them permit more precise matching of items between countries.

Representativity versus comparability

~~18.269~~18.273 Two critical criteria in selecting products to be priced for calculating PPPs are "representativity" and "comparability". Representative products are those products that are frequently purchased by resident households and are likely to be widely available throughout a country. Representativity is an important criterion in the ICP because the price levels of non-representative products are generally higher than those of representative products. Therefore, if one country prices representative products while another prices non-representative products in the same expenditure category, then the price comparisons between the countries will be distorted. On the other hand, comparability relates to the physical characteristics of a product. Products are considered to be comparable if their physical characteristics, such as size and quality, and economic characteristics, such as whether candles are used as a primary source of light or are primarily decorative, are identical.

~~18.270~~18.274 In practice, difficult trade-offs are involved in selecting products that are both representative and comparable to use in calculating PPPs. The product lists for calculating PPPs are developed in a way that balances the competing aims of within-country representativity and cross-country comparability. In this respect, they are generally quite different from the products that would be priced by any individual country to compile its price indices (such as the consumer price index or any of a range of producer price indices) and which are used in producing the deflators used to calculate volume estimates in the time series national accounts. In the case of time series within a country, representativity is the key criterion in selecting the products to be priced while comparability with other countries is unimportant. Once a representative product is selected for pricing, the important issue is to price the same product in subsequent periods so that price changes in the product can be measured over time. For the ICP, representativity is required only at a point in time and not over time

Aggregation

~~18.271~~18.275 PPPs are calculated and aggregated in two stages: estimation of PPPs at the level of basic headings and aggregation across basic heading PPPs to form higher-level aggregates. The estimation of basic heading level PPPs is based on price ratios of individual products in different countries. Typically no information about quantities or expenditures is available within a basic heading and, thus, the individual price ratios cannot be explicitly weighted when deriving PPPs for the whole basic heading. Two aggregation methods dominate PPP calculations at this level, the GEKS method (described below) and the Country Product Dummy (CPD) method. A description of these methods can be found in chapters 4 and 5 of *Measuring the Real Size of the World Economy*. Weights are of crucial importance at the second stage when the basic heading PPPs are aggregated up to GDP. The main approaches used in the aggregation are summarized in the paragraphs below.

Commented [ED23]: Changed to match abbreviation used in latest ICP methodology documents.

Binary comparisons

~~18.272~~18.276 As outlined in section C, the monetary value of GDP, or one of its components, (I_V) reflects the combined differences of both price and quantities, that is: LP □ PQ □ IV or LQ □ PP □ IV . Price and volume indices may be compiled between pairs of countries using the same kinds of index number formula as those used to measure changes between time periods. A Laspeyres-type price index for country B compared with country A is defined as:

$$L_p = \sum_{i=1}^{n} \left(\frac{p_i^B}{p_i^A}\right) S_i^A \equiv \frac{\sum_{i=1}^{n} p_i^B q_i^A}{\sum_{i=1}^{n} p_i^A q_i^A} \qquad (20a)$$

and a Paasche-type index as:

$$P_p = \left[\sum_{i=1}^{n} \left(\frac{p_i^A}{p_i^B}\right)^{-1} S_i^B\right]^{-1} \equiv \frac{\sum_{i=1}^{n} p_i^B q_i^B}{\sum_{i=1}^{n} p_i^A q_i^B} \qquad (20b)$$

where the weights s_i^A and s_i^B are component shares of GDP at current values of countries A and B.

~~18.273~~18.277 Given the complementary relationships between Laspeyres and Paasche price and volume indices noted earlier, it follows that a Laspeyres-type volume index for B compared with A can be derived by deflating the ratio of the values in B to A, each expressed in their own currencies, by the Paasche-type price index (20b). A Paasche-type volume index is similarly derived by deflating the ratio of values of B to A by a Laspeyres-type price index (20a).

~~18.274~~18.278 The differences between the patterns of relative prices and quantities for two different countries tend to be relatively large, compared with those between time periods for the same country. The resulting large spread between the Laspeyres- and Paasche-type intercountry price and volume indices in turn argues for an index number formula, such as Fisher, that makes symmetric use of both country's price and quantity information.

Multilateral comparisons

~~18.275~~18.279 The need for multilateral international comparisons may arise, for example, to determine GDP aggregates for blocks of more than two countries or rankings of the volumes of GDP, or per capita GDP, for all the countries in a block. It is desirable that such rankings are transitive.

Transitivity

~~18.276~~18.280 Consider a group of *m* countries. As binary comparisons of volumes and prices may be made between any pair of countries, the total number of possible binary comparisons is equal to $m(m-1)/2$. Let the price, or volume, index for country *j* based on country *i* be written as $_iI_j$. A set of indices is said to be transitive when the following condition holds for every pair of indices in the set:

$$ {}_iI_j \text{ x } {}_jI_k = {}_iI_k \qquad (21) $$

This condition implies that the direct (binary) index for country *k* based on country *i* is equal to the indirect index obtained by multiplying the direct (binary) index for country *j* based on country *i* by the direct (binary) index for country *k* based on country *j*. If the entire set of indices is transitive, the indirect indices connecting pairs of countries are always equal to the corresponding direct indices. In practice, none of the standard index formulae in common use, such as Laspeyres, Paasche or Fisher, is transitive.

~~18.277~~18.281 The objective is to find a multilateral method that generates a transitive set of price and volume measures while at the same time assigning equal weight to all countries. There are four quite different approaches that may be used. The first approach achieves transitivity by using the average prices within the block to calculate the multilateral volume indices. The second approach starts from the binary comparisons between all possible pairs of countries and transforms them in such a way as to impose transitivity. The third method uses regression techniques to estimate missing prices by using price relatives for other products on a country-by-country basis. The fourth method is a multilateral chaining method based on linking bilateral comparisons such that countries that are most similar in their price structures are linked first.

The block approach

~~18.278~~18.282 The most widely used form of the block approach uses the average prices of the block to revalue quantities in all countries in the block. This automatically ensures transitivity. The volume index for country B relative to country A is defined in the first expression in equation (20) as:

$$ GK_Q = \frac{\sum_{i=1}^{n} \bar{p}_i q_i^B}{\sum_{i=1}^{n} \bar{p}_i q_i^A} = \frac{\sum_{i=1}^{n} \bar{p}_i\, q_i^C}{\sum_{i=1}^{n} \bar{p}_i\, q_i^A}\; x\; \frac{\sum_{i=1}^{n} \bar{p}_i\, q_i^B}{\sum_{i=1}^{n} \bar{p}_i\, q_i^C} \qquad (22) $$

and can be seen to be transitive. The average price p_i for each individual good or service is defined as its total value in the block, expressed in some common currency, divided by its total quantity:

$$ \bar{p}_i = \frac{\sum_{j=1}^{m} c^j p^j q_i^j}{\sum_{j=1}^{m} q_i^j} \text{ where } \sum_{j=1}^{m} q^j = \sum_{j=1}^{m} \frac{{v_i}^j}{{p_i}^j} \qquad (23) $$

~~18.279~~18.283 The most common block method is the Geary Khamis (GK) method in which the currency converters used in (23) are the PPPs implied by the volume indices defined by (20). In this method, the average prices and PPPs are interdependent being defined by an underlying set of simultaneous equations. In practice, they can be derived iteratively, initially using exchange rates as currency converters for average prices, for example. The resulting volume indices are then used to derive the implied set of PPPs, which are themselves used in turn to calculate a second set of average prices, volume indices and PPPs, etc.

~~18.280~~18.284 The advantages of a block method such as the GK method include:

a. The block of countries is recognized as an entity in itself;

b. The use of a single vector of prices ensures transitivity and the volume measures are additively consistent and can be presented in value terms using the average prices of the block (it is possible to present the results for a group of countries in the form of a table with countries in the columns and the final expenditure components in the rows, in which the values add up in the columns as well as across the rows); and from them a set of m-1 transitive indices that resemble the original Fisher indices as closely as possible, using the least squares criterion. Minimizing the deviations between the original Fisher indices and the desired transitive indices leads to the so-called GEKS formula, proposed independently by Gini, Elteto, Koves and Szulc.

c. It is possible to compare ratios, such as the shares of GDP devoted to gross fixed capital formation, because the same vector of prices is used for all countries.

~~18.281~~18.285 However, comparisons between any two countries, based on the multilateral block results, may not be optimally defined. It was shown in the description on transitivity that best practice price and volume comparisons between countries A and B should make symmetric use of information on their prices and quantities. If A's relative prices are higher than average and B's are lower, the use of average prices decreases A's expenditures expressed in average international prices and increases those of B relative to a country whose prices are close to the international average. Such a disparity is often noted in the case of services between developed and developing countries. Consequently, when using the GK method, PPP-based expenditures are generally overstated for poor countries.

The binary approach

~~18.282~~18.286 An alternative approach to the calculation of a set of multilateral volume measures and PPPs is to start from the binary comparisons between all possible $m(m-1)/2$ pairs of countries. If each binary comparison is considered in isolation, the preferred measure is likely to be a Fisher index.

~~18.283~~18.287 Fisher indices are not transitive but it is possible to derive and the summation is over the *m* different countries in the block. The term *c j* in expression (23) is a currency converter which could be either a market exchange rate or a PPP used to convert each country's expenditure on item i, *vi* *pi qi* into the common currency.

~~18.284~~18.288 The GEKS index between countries *i* and *k* is the geometric average of the direct index between *i* and *k* and every possible indirect index connecting countries *i* and *k*, in which the direct index is given twice the weight of each indirect index. Transitivity is achieved by involving every other country in the block in the GEKS index for any given pair of countries.

~~18.285~~18.289 The GEKS index:

a. provides the best possible transitive measure for a single aggregate between a pair of countries, in much the same way as a chain Fisher index may provide the best possible measure of the movement of a single aggregate over time;

b. gives equal weights to the two countries being compared; and

c. is not affected by the relative sizes of the countries, a desirable attribute.

However, the consequences are similar to those for chain indices in a time series context. It is not possible to convert the GEKS volume indices for an aggregate and its components into a set of additively consistent values. This is in contrast to the GK method.

Ring comparisons

~~18.286~~18.290 The outline of the above methods assumes that there is one set of comparisons comprising all the countries in a block. As the number of countries participating increases, it becomes difficult to administer them as a single group. Moreover, it is difficult to find items that are both nationally representative and globally comparable at the same time for countries far apart both geographically and in their level of development. There are thus advantages to a regionalized approach to the compilation of PPPs. Product specifications are prepared for each region and independent sets of PPPs prepared for countries on a region by region basis.

~~18.287~~18.291 ~~While this approach probably improves the quality of PPPs at the regional level, there is still the need to combine the regions to obtain a global comparison. Traditionally, a "bridge country" was chosen to provide the link between regions. The bridge country participated in the price surveys of more than one region. The ring approach extends this idea and identifies a subset of countries in each region to act as "ring countries". These countries comprise a synthetic "region" that intersects with all of the regions whose comparisons are to be linked together.~~A global core list is added to the regional lists of goods and services for the main price survey on household consumption. This common list provides the basis to link the within-region PPPs across regions. Each region decides which elements of the core list will be part of its regional data collection. Thus, every country's data is used to estimate the between-region linking factors.

~~18.288~~18.292 The method chosen depends on a number of factors including the purpose of the analysis, level of aggregation, sparseness of data, whether the aggregation is within regions, across ring countries, or for the whole data set and the importance attributed to additivity and symmetric treatment of countries.

3. Practical considerations for national accountants

PPPs and the national accounts

~~18.289~~18.293 One of most important uses of PPPs is to calculate comparable estimates of GDP and its major components, expressed in a common currency where the effects of differences in price levels between countries are removed. The national accounts are integral to PPP estimates in three ways. In the first place, the national accounts provide the weights that are used to aggregate prices from a detailed level to broader aggregates, up to GDP itself. Secondly, the national accounts provide the values that are "deflated" by the PPPs to provide the volumes (also referred to as "real expenditures") expressed in a common currency that enable GDP and its expenditure components to be compared between countries. Thirdly, comparisons can be made of aggregates below the level of GDP.

~~18.290~~18.294 The PPP exercise also produces comparative price level indices (PLI). A PLI is the ratio of the PPP for a country relative to the official exchange rate, both measured with respect to a reference currency. PLIs are generally expressed on a base of 100, with the base being either a single reference country or a regional average.

~~18.291~~18.295 If a country has a PLI less than 100, then its price level is lower than the numeraire country (or region). Similarly, any pair of countries can be compared directly. If one has a PLI less than the other, then the country with the lower PLI would be considered "cheap" by the other country, regardless of whether its PLI is above or below 100.

~~18.292~~18.296 In practice, PPPs do not change rapidly over time and so a large change in a country's PLI is usually due to a large change in exchange rates.

~~18.293~~18.297 PPP-based volumes are often expressed as "time series", which they are not. Each year is a comparison between countries in isolation from other years. It is important that the volumes in the ICP not be confused with the time series volumes described earlier in this chapter because they are different measures, although there are some similarities in that they are both designed to measure values that have had the direct effects of price differences removed from them. In a time series of volumes, the effects of price changes from one period to another are removed to produce the volume measures from which rates of economic growth are calculated. In the case of an intercountry comparison, which is the basis for PPP- based volume measures, the effects of differences due to exchange rates and those due to different price levels within each country are removed from the national accounts values to provide a comparison between the volumes in the countries concerned.

~~18.294~~18.298 The lowest level for which PPPs can be compared across all countries involved in a comparison is referred to as the "basic heading" and it is also the lowest level for which national accounts values are required as weights. In effect, the national accounts values provide the weights to aggregate the basic heading level data to broader national accounting aggregates, including GDP itself. The basic heading is also the level at which product specifications are determined, with a number of products representative of the expenditure within each basic heading being specified for pricing.

~~18.295~~18.299 Expenditure-based estimates of GDP have been used in most PPP-based comparisons during the past half-century or so because the prices for final expenditures are more readily observable than those for outputs and inputs, which would be required for a comparison of the production- based estimates of GDP. Consistency in the national accounts is critical in producing comparable estimates across countries so the SNA has played an important part in PPP-based comparisons by providing the framework for obtaining consistent estimates of GDP and its major aggregates.

~~18.296~~18.300 The ICP is the broadest-based project to produce PPPs; the volume estimates produced from the ICP present a snapshot of the relationships between countries from all over the world, expressed in a common currency. The ICP is a very expensive and resource- consuming project and so it provides benchmarks at infrequent intervals. As a result, PPP benchmarks from the ICP have to be extrapolated using time series from the national accounts of the countries involved. It is interesting to compare the outcomes of an extrapolation with the benchmarks from two sets of PPPs compiled several years apart. In practice, the extrapolated series do not tie in exactly with the benchmarks and there are several reasons for the differences that arise. An important one is the issue of the consistency between the prices used in the time series national accounts and those used in calculating PPPs as explained in the section on representativity and comparability earlier. Further, the price and volume structure may change significantly over time in a way not picked up in the extrapolation techniques.

Why ICP growth rates differ from national growth rates

~~18.297~~18.301 The method commonly used to extrapolate PPPs from their benchmark year to another year is to use the ratio of the national accounts deflators from each country compared with a numeraire country (generally the United States of America) to move each country's PPPs forward from the benchmark. The PPPs derived are then applied to the relevant national accounts component to obtain volumes expressed in a common currency for the year in question.

~~18.298~~18.302 Theoretically, the best means of extrapolating PPPs from a benchmark year would be to use time series of prices at the individual product level from each country in the ICP to extrapolate the prices of the individual products included in the ICP benchmark. In practice, it is not possible to use this type of procedure in extrapolating PPP benchmarks because the detailed price data needed are not available in all the countries. Therefore, an approach based on extrapolating at a macro level (for GDP or for a handful of components of GDP) is generally adopted. Leaving aside the data problems involved in collecting consistent data from all the countries involved, a major conceptual question arises with this process because it can be demonstrated mathematically that it is impossible to maintain consistency across both time and space. In other words, extrapolating PPPs using time series of prices at a broad level such as GDP will not result in a match with the benchmark PPP-based estimates even if all the data are perfectly consistent.

~~18.299~~18.303 One of the reasons for differences between GDP time series and PPP benchmark comparisons stems from the definition of a product. As explained in paragraphs 18.66 to 18.67, location is an essential product characteristic in the national accounts whereas the PPP comparisons use average prices of the whole country. Another problem is that the weighting patterns underlying the deflators in the time series national accounts will differ from those in the PPP benchmarks over time. In addition, as noted above, the products priced for the PPPs will differ from those underlying the time series because of the requirements in spatial price indices for representativity within each country and comparability between countries, while in time series the main requirement is for consistency over time. Generally, many more products will be priced for a country's price indices than it is possible to price for calculating PPPs. Finally and often most critically, the prices underlying the deflators in the national accounts are adjusted to remove changes in quality over time and the methods of making such quality adjustments can differ significantly between countries. In particular, the extent of using hedonic methods for adjusting products whose characteristics change rapidly varies significantly from country to country. Electronic products (such as computers) feature prominently in hedonic quality adjustment, although some countries also use hedonics to quality adjust products such as clothing and housing. Comparing price changes in a country that uses hedonics in quality adjusting the price indices underlying its national accounts deflators with those in one that does not do so will lead to potentially

Formatted: Font: (Default) +Headings CS (Times New Roman), 10 pt, Complex Script Font: +Headings CS (Times New Roman), Don't snap to grid, Highlight large inconsistencies between the benchmarks and the extrapolated series.

~~18.300~~18.304 Possibly the single biggest factor that affects the difference between extrapolated GDP series and PPP benchmark results is due to exports and imports. GDP volume measures in the national accounts are unaffected by changes in terms of trade whereas they influence real GDP in spatial comparisons directly. For example, an increase in energy prices results in an increase in nominal GDP. In a spatial comparison, the outcome will be an increase in GDP volumes for energy exporting countries relative to other countries because the net trade PPPs are based on exchange rates, which do not respond to a change in the terms of trade to a significant extent in the short term. The result is that the increase in the terms of trade is treated as a volume effect in the PPP-based benchmark. On the other hand, in the national accounts of energy exporting countries, GDP volumes remain unchanged if the same amount of energy is exported and so the increase in the terms of trade is treated as a price effect, which is observed in the GDP deflator used as the price extrapolator.

Non-market services

~~18.301~~18.305 Another area that leads to consistency problems between countries' PPP-based volumes is the group of so-called "comparison-resistant services". They are predominantly (although not exclusively) non-market services, with government services being a major part of the non-market services that have to be priced for PPP projects. The main problems in pricing non-market services relate to the quality of the services being produced and the productivity of the labour used in producing them. One of the conventions used in producing the estimates for the government sector in most countries' national accounts is that the value of output is measured as the sum of the labour and material inputs used in producing the service(s), which involves an assumption that an increase in costs translates into an equivalent increase in output. In addition, when output indicators are not available, an assumption that is sometimes made in the national accounts is that the productivity of the labour involved in producing such services does not change over time either. A similar assumption, that productivity is identical in all the countries in a comparison, generally has to be made between countries in calculating PPPs. It is a reasonable assumption when countries at roughly the same level of economic development are involved in the PPP comparison. However, when countries at very different levels of economic development are being compared then the validity of the assumption breaks down.

~~18.302~~18.306 The choices faced by the compilers of PPPs are either to assume that productivity levels are identical across countries, even when they are at very different stages of economic development, or to adjust the non-market services estimates in some way to account for productivity differences. Apart from the problems involved in determining an appropriate conceptual approach to adjust for productivity differences between disparate economies, obtaining the data required to make such adjustments also proves problematical particularly when the method involves adjustments based on relative levels of capital intensity in the countries involved. Despite the problems, it is sometimes necessary to make productivity adjustments for non-market services because the problems involved in doing so are rather less than the consequences of assuming equal productivity in all the countries in a comparison.

Conclusion

~~18.303~~18.307 PPP-based comparisons of activity levels between countries are an important use of national accounts. Despite the conceptual and empirical difficulties, PPP-based volumes provide a much firmer basis for international comparisons than the commonly used alternative of converting national accounts aggregates to a common currency using exchange rates.

4. Productivity comparison across countries

~~18.304~~18.308 Productivity growth is often expressed in percentage terms and comparisons across countries are made in terms of these percentages. Assuming similar methods have been used to compile the estimates for the countries being compared, and that they have roughly comparable levels of productivity, this sort of comparison is interesting and much simpler than the alternative of comparing levels. Measuring the relative

Commented [ED24]: New subsection drawn from paras. 19.74-19.75 of 2008 SNA.

levels of production (for example, the volume of GDP or of GDP per capita) or productivity between countries is more complicated because it is necessary to convert the national accounts data to a common currency. The best means of doing so is to calculate purchasing power parities (PPPs), which measure the rate of currency conversion that would be required to equalize the prices of a common basket of goods and services between the countries concerned. In practice, PPPs adjust for differences in price levels between countries as well as differences in exchange rates.

~~18.305~~18.309 The PPP International comparisons of productivity below the level of GDP, such as by industry, are problematic. PPPs are calculated using the expenditure-based estimates of GDP so there are no PPPs for the individual industries that contribute to GDP. Therefore, it is necessary to make an assumption that the PPP for a single aggregate such as GDP is applicable to all industries. Examining the differences in the PPPs for the various expenditure components shows they can vary significantly so this is unlikely to be a very good assumption. Making robust international comparisons of productivity at disaggregated levels is thus a very demanding exercise, though considerable progress has been made in recent years.