XVI. Price and volume measures

A. Introduction

16.1. The System provides a framework within which an integrated set of price and volume measures can be compiled which are conceptually consistent and analytically useful. The primary objective is not simply to provide comprehensive measures of changes in prices and volumes for the main aggregates of the System but to assemble a set of interdependent measures which make it possible to carry out systematic and detailed analyses of inflation and economic growth and fluctuations.

16.2. Changes over time in the values of flows of goods and services can be directly factored into two components reflecting changes in the prices of the goods and services concerned and changes in their volumes. Similarly, changes in the values of stocks of many kinds of assets can usually also be decomposed into their own price and volume components. However, many flows in the System, such as cash transfers, do not have price and quantity dimensions of their own and cannot, therefore, be decomposed in their way. Such flows cannot be measured at constant prices but can nevertheless be measured "in real terms" by deflating their values by price indices in order to measure their real purchasing power over some selected basket of goods and services that serves as numeraire. However, there may be more than one way to do this. There may be no obvious choice of numeraire in which to measure the purchasing power and it may well be appropriate to choose different numeraires for the units paying and receiving the same transfers when these are different kinds of units—e.g., government units and households. Moreover, a flow such as wages and salaries can be treated in two quite different ways. For purposes of analysing production and productivity in which wages and salaries constitute costs of production, it may be necessary to measure inputs of labour at constant input prices—i.e., at constant wage and salary rates—whereas when wages and salaries are recorded as receivables in the primary distribution of income account they may need to be measured in terms of their purchasing power over some basket of final household consumption goods and services.

16.3. As the impact of changes in prices may need to be treated differently for the two parties to the same transaction it is not possible to compile a single, consistent multi-purpose set of accounts in real terms embracing all entries in the accounts that would be useful for all types of economic analysis. On the other hand, it is feasible to compile a consistent and integrated set of price and volume measures covering all flows of goods and services, as recorded in the supply and use tables, for example, and this chapter is mainly concerned with the methods that may be used for this purpose. In the final section of the chapter, however, the measurement of real income, as distinct from real product, is examined at the level of the total economy.

16.4. 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 difficult at current as well as constant prices. Free standing indices, such as consumer price indices or industrial production indices, present far fewer problems because they are much more restricted in their coverage.

16.5. Another advantage of compiling price and volume measures within an accounting framework is that price or volume measures can be derived for certain important balancing items. In particular, gross value added can be measured at constant prices by subtracting intermediate consumption at constant prices from output at constant prices, the so-called "double deflation" method. Double deflation may be used at the level of an individual enterprise, industry or sector, or for the total economy as a whole by subtracting imports at constant prices from total final expenditures at constant prices.

16.6. 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 and also to compare the price levels in different countries when prices are converted at exchange rates. Such comparisons are important both for purposes of economic analysis and policy-making. The additional methodological questions raised by international comparisons are dealt with in a separate section below.

16.7. The contents of this chapter may be summarized as follows:

(*a*) The first group of sections is concerned with inter-temporal price and volume index numbers: i.e., with the choice of an appropriate methodology for compiling intertemporal price and volume measures for flows of goods and services in a national accounting context. The construction of a set of suitable price and volume indices for the flows of goods and services in the System is the essential first step, even if it is intended to go on to utilize the resulting price indices to compile measures of real income at a later stage;

(*b*) Another section examines the methodology for compiling international price and volume measures for purposes of comparing living standards or productivity levels in different countries in the same period of time;

(*c*) Another section deals with the consequences of price variation and price discrimination: that is, how to treat goods or services that are sold to different purchasers at different prices on the same market in the same period of time. Such differences need to be clearly distinguished from price differences attributable to differences in qualities;

(*d*) Another section is concerned with the treatment of changes in quality over time, including the appearance of new products and the disappearance of old products, and also with differences in the quality of products found in different countries. This can be most difficult, and the most serious practical problem encountered in the construction of both intertemporal and international price and volume indices. This section includes a brief description of the use of the hedonic hypothesis to adjust for changes in quality over time, or differences in quality between countries, especially for high technology products and fixed assets;

(*e*) The final section considers the differences between real product and real income at the level of the total economy. These differences may be quite substantial over certain periods of time for open economies that experience substantial changes in their terms of trade with other countries.

B. Values, prices and quantities

16.8. 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:

(*a*) Automobiles, aircraft, microcomputers, haircuts, appendectomies, etc., are examples of goods or services provided in discrete or integral units, described by generic terms such as "automobile". The quantities of such goods and services are obtained simply by counting the number of units;

(*b*) Oil, electricity, sugar, transportation, etc., are examples of goods or services provided in units that vary continuously in respect of characteristics such as weight, volume, power, duration, distance, etc. The choice of physical unit is therefore a matter of convenience: for example, it may be one pound, one kilo or one ton; one gallon or one litre; one minute or one hour; etc. The price of such a good or service is quoted in relation to the particular physical unit selected. Its absolute value is therefore quite arbitrary: for example, if the price is quoted per ton it is one thousand times greater than if it is quoted per kilo.

16.9. 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,

$$v = pq$$

In contrast to price, value is independent of the choice of quantity unit. Values have quite different dimensions from prices and the terms "value" and "price" cannot be used interchangeably for each other. Certain important properties of quantities, prices and values may be briefly noted:

(*a*) Quantities are additive only for a single homogeneous product. Quantities of different products are not commensurate and not additive even when measured in the same kinds of physical units. For example, it is not economically meaningful to add 10 tons of coal to 20 tons of sugar, even though their combined weight of 30 tons may provide relevant information for other purposes, such as loading ships or vehicles. Less obviously, the addition of 10 automobiles of one type to 20 automobiles of another type may also not be economically meaningful (see below);

(*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 can therefore be made to vary arbitrarily in many cases by choosing to measure in tons, for example, instead of in kilos. 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 commensurate and additive across differ-

ent products. As already noted, values are invariant to the choice of quantity unit.

16.10. The aggregation of the values of different goods and services is justified by the fact that, 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.

Volumes

16.11. 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 must be homogeneous, while the changes for different goods and services must be weighted by their economic importance as measured by their values in one or other, or both, periods. The concept of a volume index may be illustrated by a simple example. Consider an industry that produces two different models of automobile, one selling for twice the price of the other. From an economic point of view these are two quite different products even though described by the same generic term "automobile". Suppose that between two periods of time:

(*a*) The price of each model remains constant;

(*b*) The total number of automobiles produced remains constant;

(*c*) The proportion of higher priced models produced increases from 50 per cent to 80 per cent.

It follows that the total value of the output produced increases by 20 per cent because of the increase in the proportion of higher-priced models. This constitutes a volume increase of 20 per cent. As each higher-priced automobile constitutes twice as much output as each lower-priced automobile, a switch in production from low- to high-priced models increases the volume of output even though the total number of automobiles produced remains unchanged. The fact that the value increase is entirely attributable to an increase in volume also follows from the fact that no price change occurs for either model. The price index must remain constant in these circumstances.

16.12. The term "volume increase" is used in preference to "quantity increase" because there is a possible ambiguity about the use of the term "quantity increase". It is sometimes argued that the situation described in the example is one in which the quantities remain unchanged (because the total number of automobiles remain unchanged), whereas the average quality of the automobiles produced increases (because of the increase in the proportion of higher-priced models). However, such an interpretation is based on a semantic confusion due to the fact that the same generic term, "automobile", is applied to two products that are actually quite different from an economic point of view. It is not legitimate to add together quantities that are not identical with each other, even though they may be measured in the same kind of physical units. Adding together quite different models of "automobiles" is no more meaningful than adding together tons of different kinds of "foods"—for example, adding tons of rice to tons of apples or beef. In general, it is not possible to decompose a volume change into a quantity change and a change in average quality. The so-called "quantity index" has no meaning from an economic point of view if it involves adding quantities that are not commensurate. For quite different purposes, however, such as loading aircraft, ships or vehicles, adding quantities may provide useful information. Similarly, for purposes of traffic control or pollution, it may be useful to know the increase in the total numbers of vehicles produced or imported, irrespective of their price. However, such measures are not volume measures in an economic sense.

Quantity and unit value indices

16.13. Unfortunately, it may sometimes happen, especially in the field of foreign trade statistics, that as a result of lack of information the data on which price and volume indices have to be calculated are not adequate for the purpose. For example, the basic information available may be limited to the total numbers of units of some group of products imported or exported, or their total weight: for example, the total numbers of pairs of shoes, or total weight of equipment of 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 as they measure the change in the average value of units that are not homogeneous and may therefore 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.

C. Intertemporal index numbers of prices and volumes

1. Introduction

16.14. A price index is an average of the proportionate changes in the prices of a specified set of goods and services between two periods of time. Similarly, a volume index is an average of proportionate changes in the quantities of a specified set of goods and services. As already emphasized, the price and quantity changes refer to individual goods or services as distinct from groups of similar products. Different qualities of the same

kind of product must be treated as separate goods or services in this context.

16.15. In line with normal conventions, the period that serves as the reference point will be designated as period *o* and the period which is compared with it designated as period *t*. The two periods may be consecutive or be separated by intervening periods. The ratio of the price, or quantity, of a specific product in period *t* to the price, or quantity, of the same product in period *o*, is described as a price relative, or quantity relative: namely, p_t/p_o or q_t/q_o. Price and quantity relatives are pure numbers that are independent of the units in which the quantities are measured and the prices are quoted. Most index numbers can be expressed as, or derived from, weighted averages of these price or quantity relatives, the various formulas differing from each other mainly in the weights which they attach to the individual price or quantity relatives and the particular form of averages used—arithmetic, geometric, harmonic, etc.

2. Laspeyres and Paasche indices

16.16. The two most commonly used indices are the Laspeyres and Paasche indices. Both may be defined as weighted averages of price or quantity relatives, the weights being the values of the individual goods or services in one or other of the two periods being compared.

Let $v_{ij} = p_{ij}\, q_{ij}$: the value of the *i*th product in period *j*

The Laspeyres price index (Lp) is defined as a weighted arithmetic average of the price relatives using the values of the earlier period *o* as weights:

$$Lp = \sum_i \frac{v_{io} \cdot p_{it}/p_{io}}{\sum_i v_{io}} \qquad (1)$$

where the summation takes place over different goods and services. The Laspeyres volume index (Lq) is a similar weighted average of the quantity relatives, that is:

$$Lq = \sum_i \frac{v_{io} \cdot q_{it}/q_{io}}{\sum_i v_{io}} \qquad (2)$$

The period that provides the weights for an index is described as the "base" period. It usually (but not always) coincides with the reference period to which the comparisons relate. As the summation always takes place over the same set of goods and services it is possible to dispense with the subscript *i* in expressions such as (1) and (2). As v_j is equal to $p_j q_j$ by definition, it is also possible to substitute for v_j in (1) and (2) to obtain:

$$Lp = \frac{\sum p_t q_o}{\sum p_o q_o} \qquad (3)$$

and

$$Lq = \frac{\sum p_o q_t}{\sum p_o q_o} \qquad (4)$$

Expressions (1) and (3) are algebraically identical with each other, as are (2) and (4).

16.17. Paasche price and volume indices are defined reciprocally to Laspeyres indices by using the values of the later period *t* as weights and a harmonic average of the relatives instead of an arithmetic average. A Paasche index (P_p or P_q) is defined as follows:

$$P_p = \frac{\sum v_t}{\sum v_t \cdot p_o/p_t} = \frac{\sum p_t q_t}{\sum p_o q_t} \qquad (5)$$

and

$$P_q = \frac{\sum v_t}{\sum v_t \cdot q_o/q_t} = \frac{\sum p_t q_t}{\sum p_t q_o} \qquad (6)$$

When a time series of Paasche indices is compiled, the weights therefore vary from one period to the next.

16.18. The Paasche index may also be interpreted as the reciprocal of a "backward looking" Laspeyres: that is, the reciprocal of a "Laspeyres" index for period *o* that uses period *t* as the base period. Because of this reciprocity between Laspeyres and Paasche indices there are important symmetries between them. In particular, the product of a Laspeyres price (volume) index and the corresponding Paasche volume (price) index is identical with the proportionate change in the total value of the flow of goods or services in question, that is:

$$L_p \cdot P_q = \frac{\sum p_t q_o}{\sum p_o q_o} \frac{\sum p_t q_t}{\sum p_t q_o} = \frac{\sum v_t}{\sum v_o} \qquad (7)$$

and

$$L_q \cdot P_p = \frac{\sum p_o q_t}{\sum p_o q_o} \frac{\sum p_t q_t}{\sum p_o q_t} = \frac{\sum v_t}{\sum v_o} \qquad (8)$$

This relationship can be exploited whenever the total values for both periods are known. When both Σv_t and Σv_o are known, one or the other out of a complementary pair of Laspeyres and Paasche indices can be derived indirectly. For example,

$$L_q = \frac{\sum v_t / \sum v_o}{P_p} \qquad (9)$$

and

$$P_q = \frac{\sum v_t / \sum v_o}{L_p} \qquad (10)$$

Thus, the Laspeyres volume index can be derived indirectly by dividing the proportionate change in values by the Paasche price index, a procedure described as price deflation. As it is usually easier, and less costly, to calculate direct price than direct volume indices, it is common to obtain volume measures indirectly both in national accounts and economic statistics generally.

Values at constant prices

16.19. Consider a time series of Laspeyres volume indices, namely:

$$\frac{\Sigma p_0 q_0}{\Sigma p_0 q_0}, \frac{\Sigma p_0 q_1}{\Sigma p_0 q_0} \cdots \frac{\Sigma p_0 q_t}{\Sigma p_0 q_0} \qquad (11)$$

Multiplying through the series by the common denominator $\Sigma p_0 q_0$ yields the constant price series:

$$\Sigma p_0 q_0 \ , \ \Sigma p_0 q_1 \ \cdots \ \Sigma p_0 q_t \qquad (12)$$

The relative movements from period to period for this series are identical with those of the associated Laspeyres volume indices given by (11), the two series differing only by a scalar. Constant price series of the kind illustrated by (12) are easy to understand and used extensively in national accounts. The term volume "measure" is used to cover both time series of monetary values at constant prices and the corresponding series of volume index numbers.

3. The relationship between Laspeyres and Paasche indices

16.20. Before considering other possible formulas, it is necessary 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 time than a Paasche index:

that is, in general

$$\text{both } L_p > P_p \text{ and } L_q > P_q \qquad (13)$$

It can be shown that relationship (13) holds whenever the price and quantity relatives (weighted by values) are negatively correlated. Such negative correlation is to be expected for price takers 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. In the vast majority of situations covered by index numbers, the price and quantity relatives turn out to be negatively correlated so that Laspeyres indices tend systematically to record greater increases than Paasche with the gap between them tending to widen with the passage of time.

The economic theoretic approach to index numbers

16.21. From the point of view of economic theory, the observed quantities may be assumed to be functions of the prices, as specified in some utility or production function. Assuming that a consumer's expenditures are related to an underlying utility function, a cost of living index may then be defined as the ratio of the minimum expenditures required to enable a consumer to attain the same level of utility under the two sets of prices. It is equal to the amount by which the money income of a consumer needs to be changed in order to leave the consumer as well off as before the price changes occurred. This amount depends not only on the consumer's preferences, or indifference map, but also on the initial level of income and expenditures of the consumer. The value of the theoretic index is not the same for different consumers with a different set of preferences, nor even for the same consumer starting from different income levels.

16.22. The following conclusions may be drawn about the relationships between Laspeyres, Paasche and the underlying theoretic cost of living indices:

(*a*) The Laspeyres index provides an upper bound to the theoretic index. Suppose the consumer's income were to be increased by the same proportion as the Laspeyres index. It follows that the consumer must be able to purchase the same quantities as in the base period and must therefore be at least as well off as before. However, by substituting products that have become relatively less expensive for ones that have become relatively more expensive the consumer should be able to obtain a higher level of utility. This substitution will set up a negative correlation between the price and quantity relatives. As the consumer can thereby attain a higher level of utility, the Laspeyres price index must exceed the theoretic index;

(*b*) Similarly, the Paasche index can be shown to provide a lower bound to the theoretic index based on the later period. The reasoning behind this runs along the same lines as that just used for the Laspeyres index.

16.23. While these conclusions show that the Laspeyres and Paasche indices provide upper and lower bounds to the corresponding theoretic indices, it must be noted that two theoretic indices are involved and not one. The theoretic index depends upon the situation in the base period and income level which are not the same in the two periods. However, if it can be assumed that the preferences of the consumer are homothetic—i.e., if each indifference curve is a uniform enlargement, or contraction, of each other—the two theoretic indices coincide. In this case, the Laspeyres and Paasche indices provide upper and lower bounds to the same underlying theoretic index. This is still not sufficient to identify the latter. In order to do this it is necessary to go one step further by specifying the precise functional form of the indifference curves. As early as 1925 it was proved that if the utility function can be represented by a homogeneous quadratic function (which is homothetic) Fisher's Ideal Index (F) is equal to the underlying theoretic index. Although a spe-

cial case, this result has had a considerable influence on attitudes towards index numbers.

16.24. Fisher's Ideal Index (F) is defined as the geometric mean of the Laspeyres and Paasche indices, that is:

$$F_p = \left(L_p \,.\, P_p\right)^{1/2} \tag{14}$$

and

$$F_q = \left(L_q \,.\, P_q\right)^{1/2} \tag{15}$$

Fisher described this index as "ideal" because it satisfies various tests that he considered important, such as the "time reversal" and "factor reversal" tests. The time reversal test requires that the index for *t* based on *o* should be the reciprocal of that for *o* based on *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, $\Sigma v_t / \Sigma v_o$. Laspeyres and Paasche indices on their own do not pass either of these tests. On the contrary, assuming the relationships given in (13) hold, it follows from (7), (8) and (13) that:

$$L_p \,.\, L_q > \Sigma v_t / \Sigma v_o \tag{16}$$

while

$$P_p \,.\, P_q < \Sigma v_t / \Sigma v_o \tag{17}$$

so that neither index passes the factor reversal test.

16.25. The Fisher index therefore has a number of attractions that have led it to be extensively used in general economic statistics. However, it is worth noting that it also has some disadvantages, some practical, some conceptual:

(*a*) The Fisher index is demanding in its data requirements as both the Laspeyres and the Paasche indices have to be calculated, thereby not only increasing costs but also possibly leading to delays in calculation and publication;

(*b*) The Fisher index is not so easy to understand as Laspeyres or Paasche indices which can be interpreted simply as measuring the change in the value of a specified basket of goods and services;

(*c*) The particular preference function for which Fisher provides the exact measure of the underlying theoretic index is only a special case;

(*d*) The Fisher index is not additively consistent. As explained below, it cannot be used to create an additive set of "constant price" data.

16.26. Although the underlying theoretic index may be unknown, the Fisher index seems likely to provide a much closer approximation to it than either the Laspeyres or Paasche indices on their own. However, the Fisher index is not alone in this respect. It has been shown that any symmetric mean of the Laspeyres and Paasche indices is likely to approximate the theoretic index quite closely, the Fisher index being only one example of such a symmetric mean.

16.27. The notion of symmetry can be extended to describe any index that attaches equal weight or importance to the two situations being compared. Another important example of a symmetric index is the Tornqvist, or translog, index (T) the volume version of which is defined as follows:

$$T_p = \prod \left\{ \left(q_t / q_o\right)^{1/2(s_o + s_t)} \right\} \tag{18}$$

where s_o and s_t denote the share of the total values ($v / \Sigma v$) accounted for by each product in the two periods. The Tornqvist index is a weighted geometric average of the quantity relatives using arithmetic averages of the value shares in the two periods as weights. The Tornqvist price index is obtained by replacing the quantity relatives (q_t / q_o) in (18) by price relatives (p_t / p_o).

16.28. The Tornqvist index is commonly used to measure volumes changes for purposes of productivity measurement. When the production possibilities being analysed can be represented by a homogeneous translog production function, it can be shown that the Tornqvist index provides an exact measure of the underlying theoretic volume index. Thus, the Tornqvist index, like the Fisher index, provides an exact measure under certain very specific circumstances. Both indices are examples of "superlative indices": i.e., indices that provide exact measures for some underlying functional form that is "flexible", the homogeneous quadratic and homogeneous translog functions being particular examples of such flexible functional forms.

16.29. The Tornqvist index, like the Fisher, utilizes information on the values in both periods for weighting purposes and attaches equal importance to the values in both periods. For this reason, its value may be expected to be close to that of an average of the Laspeyres and Paasche indices, such as the Fisher, especially if the index number spread between them is not very large. The difference between the numerical values of the Tornqvist and Fisher indices is likely to be small compared with the difference between either of them and the Laspeyres or Paasche indices.

16.30. Thus, economic theory suggests that, in general, a symmetric index that assigns equal weight to the two situations being compared is to be preferred to either the Laspeyres or Paasche indices on their own. The precise choice of symmetric index—whether Fisher, Tornqvist or other superlative index—may be of only secondary importance as all the symmetric indices are likely to approximate each other, and the underlying theoretic index, fairly closely, at least when the index number spread between the Laspeyres and Paasche is not very great.

D. Chain indices

1. The rebasing and linking of indices

16.31. It is convenient to start by considering the example of a time series of Laspeyres volume indices on a fixed base period and its associated series of values at constant prices. In the course of 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 at which it becomes unacceptable to continue using them to measure volume measures from one period to the next. It may then be necessary to update the base period and to link the old series to the series on the new base period.

16.32. For a single index taken in isolation linking is a simple arithmetic operation. However, within an accounting framework it is not possible to preserve the accounting relationships between an aggregate and its components while at the same time linking the aggregate and its components separately. The difficulties involved are best explained by referring to the numerical example given in table 16.1.

16.33. Part I of the table presents the underlying price, quantity and value data for two products, A and B, and the aggregate (A+B). It is assumed that constant price series are calculated for periods 0 to 10 using period 0 prices, with a change of base year in period 10. Constant price data for periods 10 onwards are calculated at period 10 prices. The resulting constant price data, and the Laspeyres volume indices for the aggregate, are shown in part II of the table. The question to be addressed is the best way to link these two *sets* of data as a whole.

16.34. Assuming it is desired to present a continuous run of "constant price" data from period 0 to period 15, there are several ways in which such data could be compiled. One possibility is to scale down the constant price data from periods 10 to 15 (calculated at period 10 prices) to the general level of prices in period 0 by multiplying through by a constant equal to $\Sigma p_0 q_{10} / \Sigma p_{10} q_{10}$. This ensures that there is no break in continuity for the aggregate when the weights are switched from period 0 prices to period 10 prices. It yields a set of data which, from period 10 onwards, is expressed at the general price level of period 0 but at the relative prices of period 10. This solution is illustrated in part III of the table.

16.35. The difficulty with this solution is apparent from the table. In period 10 in which the link occurs two different sets of relative prices have to be used. As a result, discontinuities are introduced into the "constant price" series for A and B at the point at which the switch is made from one set of relative prices to the other. For this reason, the linked measures for A and B do not reflect the underlying volume movements. For example, the ratio of the "constant price" figure for A in period 15 to the corresponding value in period 0, namely 71.9/30 = 2.40, is very different from the actual change in the quantity of A, namely 15/5 = 3.

16.36. The same difficulties would arise if the series before the link were to be scaled up to the general price level of period 10. As illustrated in part IV of table 16.1 the constant price data valued at the prices of period 0 can be scaled up to the prices of period 10 by multiplying by the constant $\Sigma p_0 q_{10} / \Sigma p_0 q_0$. Discontinuities are again created for A and B at the point at which the switch is made from one set of relative prices to the other. The ratio of the "constant price" for A in period 15 to that in period 0 is 135/56.4 = 2.39 which again is very different from the actual quantity change, 3.

16.37. In order to preserve the volume movements at each level of aggregation, components have to be linked as well as the aggregates. This procedure is followed in parts V and VI of table 16.1. In part V the linked values are at the constant prices of period 0 while in part VI they are at the constant prices of period 10. The linked volume movements for A and B reflect the underlying quantity changes, while the linked volume movements for the aggregate A + B take account of the change in weights in period 10. The problem that emerges with this method is that the constant price values for the components do not add up to the constant price values of the aggregates after the series have been linked. This can be seen in part V for the linked values of period 15 at prices of 0 and in part VI for the linked values of period 0 at the prices of 15. In other words when every series at each level of aggregation is individually linked, the resulting constant price data are not additively consistent after the linking has taken place.

16.38. When data are not additively consistent, as in the last column of part V and the first column of part VI, there is a discrepancy between the sum of the components and the corresponding aggregate at each individual level of aggregation. One way of eliminating the discrepancy would be to distribute it in proportion to the components. For example, the figures of 45 and 80 in the first column could be scaled down 42.9 and 74.6 to make them add to 116.5, the required total. However, this would automatically distort the volume comparisons for both A and B in period 0 as compared with periods 10 and 15. Alternatively, the total for (A+B) could be adjusted to make it equal to the sum of the components, i.e., 125 instead of 116.5. By distorting the volume comparisons at the aggregate level, however, this would defeat the main purpose of the exercise.

16.39. A choice has to be made between the two different methods illustrated in the table. The first approach, using the scalar adjustment as illustrated in parts III and IV of the table, preserves additive consistency at the expense of distorting the linked comparisons at a detailed level. The second approach, illustrated in parts V and VI, preserves the validity of the linked comparisons at each level of aggregation at the cost of destroying additive consistency. The volume movements for the overall aggregate are the same in both cases. On balance,

Table 16.1. The rebasing and linking of volume indices and series at constant prices: a numerical example

I. The basic data

Product	Period 0			Period 10			Period 15		
	p_0	q_0	v_0	p_{10}	q_{10}	v_{10}	p_{15}	q_{15}	v_{15}
A	6	5	30	9	12	108	11	15	165
B	4	8	32	10	11	110	14	11	154
A+B	-	-	62			218			319

II. Laspeyres

Product	Base year 0		Base year 10	
	Period 0	Period 10	Period 10	Period 15
	p_0q_0	p_0q_{10}	$p_{10}q_{10}$	$p_{10}q_{15}$
A	30	72	108	135
B	32	44	110	110
A+B	62	116	218	245
Index	100	187.1	100	112.4
Linked index (0)	100	187.1	187.1	210.3
Linked index (10)	53.4	100	100	112.4

III. Linking by scaling down values from periods 10 to 15 by ratio $\Sigma p_0q_{10}/\Sigma p_{10}q_{10}$ = 116/218

Product	Actual values		Scaled down to 0 price level	
	p_0q_0	p_0q_{10}	$p_{10}q_{10}$	$p_{10}q_{15}$
A	30	72	57.5	71.9
B	32	44	58.5	58.5
A+B	62	116	116	130.4
Linked index	100	187.1	187.1	210.3

IV. Linking by scaling up values from periods 0 to 10 by ratio $\Sigma p_{10}q_{10}/\Sigma p_0q_{10}$ = 218/116

Product	Scaled up to 10 price level		Actual values	
	p_0q_0	p_0q_{10}	$p_{10}q_{10}$	$p_{10}q_{15}$
A	56.4	135.3	108	135
B	60.1	82.7	110	110
A+B	116.5	218	218	245
Linked index	53.4	100	100	112.4

Table 16.1 The rebasing and linking of volume indices and series at constant prices: a numerical example (*cont.*)

V. Linking individual series at prices of period 0

Product	p_0q_0	p_0q_{10}	p_0q_{15} (linked)
A	30	72	90
B	32	44	44
A+B	62	116	130.4
Linked index	100	187.1	210.3

VI. Linking individual series at prices of period 10

Product	$p_{10}q_0$ (linked)	$p_{10}q_{10}$	$p_{10}q_{15}$
A	45	108	135
B	80	110	110
A+B	116.5	218	245
Linked index	53.4	100	112.4

the second method seems preferable, given that the main purpose is to obtain good price and volume measures.

16.40. When the base year is updated for constant price series in national accounts, the problem is how to present data for years prior to the new base year. In practice, the method illustrated in part VI of the table is usually followed which preserves the integrity of the volume movements at each level of aggregation at the cost of destroying additivity for years prior to the new base year. The question of how to deal with the resulting discrepancies is considered further below.

2. Rebasing and linking each period

Introduction

16.41. If the objective is to measure the actual movements of prices and volumes from period to period indices should be compiled only between consecutive time periods. Changes in prices and volumes between periods that are separated in time are then obtained by cumulating the short-term movements: i.e., by linking the indices between consecutive periods together to form "chain indices". Such chain indices have a number of practical as well as theoretical advantages. For example, it is possible to obtain a much better match between products in consecutive time periods than between periods that are far apart, given that products are continually disappearing from markets to be replaced by new products, or new qualities. Chain indices are also being increasingly demanded by economists and others for analytical purposes and are being increasingly used for special purpose indices, such as consumer price indices, in order to have indices whose weighting structures are as up-to-date and relevant as possible.

Chain Laspeyres and Paasche indices

16.42. 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. A chain Laspeyres volume index connecting periods 0 and n is an index of the following form:

$$L_q^c = \frac{\Sigma p_o q_1}{\Sigma p_o q_o} \cdot \frac{\Sigma p_1 q_2}{\Sigma p_1 q_1} \cdot \ldots \frac{\Sigma p_{t-1} q_t}{\Sigma p_{t-1} q_{t-1}} \cdot \ldots \frac{\Sigma p_{n-1} q_n}{\Sigma p_{n-1} q_{n-1}} \qquad (19)$$

A chain Paasche volume index P_q^c is obtained by adding 1 to each of the price subscripts in (19). Laspeyres and Paasche price indices are obtained by interchanging the *p*'s and *q*'s in the expressions for the volume indices.

16.43. In general, Laspeyres indices, whether volume or price, tend to increase more (or decrease less) than Paasche indices, but if fixed base indices are replaced by chain indices, the index number spread between Laspeyres and Paasche is likely to be greatly reduced. The relationship between a fixed base index and the corresponding chain index is not always the same, however, as it must depend upon the paths followed by individual prices and quantities over time.

16.44. If individual prices and quantities tend to increase or decrease monotonically over time it can be shown that the chain Laspeyres will tend to increase less than the fixed weight

Laspeyres while the chain Paasche will tend to increase more than the fixed Paasche. In these circumstances, therefore, chaining will reduce the index numberspread, possibly almost eliminating it.

16.45. 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, it can be shown that the chain Laspeyres may increase faster than the fixed base Laspeyres, while the chain Paasche may increase less than the fixed Paasche. In this case, the index number spread is increased by chaining, thereby accentuating the problem of choice of formula. It is possible to give a simple demonstration of this effect.

16.46. Suppose that the changes in prices and quantities that occur between the base period 0 and some intervening period t are subsequently reversed so that by the time the final period n is reached all the individual prices and quantities have returned to their initial levels in period 0. As the prices and quantities for period *n* are identical with those in period 0, it would be reasonable to require the price and volume indices for period *n* based on period 0 to be unity. The direct Laspeyres and Paasche for period *n* based on period 0 would clearly both be unity in these circumstances. However, a chain Laspeyres (or Paasche) that used the intervening period t as a link would not be unity. The chain volume index is given the following expression:

$$\frac{\Sigma p_o q_t}{\Sigma p_o q_o} \cdot \frac{\Sigma p_t q_n}{\Sigma p_t q_t}$$

If $q_n = q_o$ by assumption for every product, then the chain index can be written as:

$$\frac{\Sigma p_o q_t}{\Sigma p_o q_o} \cdot \frac{\Sigma p_t q_o}{\Sigma p_t q_t} = L_q / P_q$$

where L_q and P_q are the Laspeyres and Paasche volume indices for period *t* based on period 0. As L_q may be expected to be greater than P_q, it follows that the chain Laspeyres is greater than unity (and therefore greater than the direct Laspeyres for period *n* on period 0). This reflects the fact that a Laspeyres index does not satisfy Fisher's "time reversal" test. The more the prices and quantities in period t diverge from those in periods 0 and n (i.e., the more the prices and quantities fluctuate), the greater the difference between L_q and P_q, and hence the more the chained Laspeyres volume index exceeds unity in this example.

16.47. If the whole process is repeated again and again, the chain Laspeyres volume index linking successive rounds together will drift further and further away from unity, even though the prices and quantities keep returning to their initial values by assumption. Such drifting is a signal that the circumstances are not appropriate for a chain index. When the sets of relative prices and quantities in two time periods are similar to each other they should be compared directly and not indirectly via another period whose relative prices and quantities are very different. A chain Laspeyres, or Paasche, index should not be used if the chaining involves an economic detour; i.e., linking through a period, or periods, in which the sets of relative prices and quantities differ more from those in both the first and the last period than the latter do from each other.

16.48. Conversely, a chain index should be used when the relative prices in the first and last periods are very different from each other and chaining involves linking through intervening periods in which the relative prices and quantities are intermediate between those in the first and last periods. Relative prices and quantities are described as intermediate when they may be approximated by some average of those in the first and last periods. This will happen when the opening prices and quantities are transformed into those of the final period by the gradual accumulation of successive changes which tend to be in the same direction. In this case, the individual links in the chain are strong as they involve comparisons between situations that are very similar to each other.

16.49. 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. However, when data are collected more frequently than once per year, regular fluctuations occur in certain monthly or quarterly data as a result of seasonal factors affecting the supply or demand for individual goods or services. Applying the conclusions reached above suggests that if it is desired to measure the change in prices or volumes between a given month, or quarter, and the same month, or quarter, in the following year, the change should be measured directly and not through a chain index linking the data over all the intervening months, or quarters. As noted above, even if the prices and quantities for a particular month, or quarter, were to be identical with those in the previous year, a chained Laspeyres volume index could not be expected to return to its previous level. Chaining seasonal data that are not adjusted for seasonal fluctuations is not desirable and fixed weight indices would be preferable. This does not preclude the use of chain indices to measure year to year changes in the corresponding annual data.

Chain Fisher or Tornqvist indices

16.50. As explained in the previous section, the index number spread between Laspeyres and Paasche indices may be greatly reduced by chaining when prices and quantities move smoothly over time, even if the cumulative changes in the relative prices and quantities are quite large in the long run leading to a wide spread between the direct Laspeyres and Paasche. Indeed, in the limit, as the time paths of prices and quantities converge

on steady exponential rates of increase or decline, the chain Laspeyres and Paasche converge on a single chain index.

16.51. When the index number spread can be reduced by chaining, the choice of index number formula assumes less significance as all relevant index numbers lie within the upper and lower bounds of the Laspeyres and Paasche indices. Nevertheless, there may still be some advantages to be gained by choosing an index such as the Fisher or Tornqvist that treats both periods being compared symmetrically.

16.52. Such indices are likely to more closely approximate the theoretic 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 chained symmetric index, such as Fisher or Tornqvist, is also likely to perform better when there are fluctuations in prices and quantities. The example given in the previous section showed that if all the price and quantity changes that occur between period 0 and t are subsequently reversed between t and n, the chain Laspeyres linking 0 to n through t does not return to unity. In other words, Laspeyres indices do not satisfy Fisher's time reversal test. However, the Fisher index does satisfy this test and returns to unity in the circumstances postulated. It may be conjectured that, in general, chain Fisher indices are likely to yield results that are more acceptable in the presence of fluctuations. While it remains desirable to avoid economic detours when compiling chain indices (i.e., linking through periods with very different economic structures) chain Fisher indices are likely to be much less sensitive to such detours than chain Laspeyres or Paasche indices.

Chaining and data coverage

16.53. 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, catastrophes of one kind or another, etc. Thus, it is not possible to compile price and quantity relatives for every product available in one or another period. In such situations the best that can be done is to compile price or quantity relatives for as many products as possible and then to assume that either the price or the volume changes for the remaining products, which include products available in only one of the two periods, are the same as for some similar product, or group of products, for which price or quantity relatives can be calculated. In general, it would be more reasonable to assume equality of price than volume changes, given that some quantities are zero in one or other period.

16.54. In a time series context, the overlap between the products available in the two periods is almost bound to be greatest for consecutive time periods (except for sub-annual data subject to seasonal fluctuations). The amount of price and quantity information that can be utilized directly for the construction of the price or volume indices is, therefore, likely to be maximized by compiling chain indices linking adjacent time periods. Conversely, the further apart the two time periods are, the smaller the overlap between the ranges of products available in the two periods is likely to be, and the more necessary it becomes to resort to indirect methods of price comparisons based on assumptions. Thus, the difficulties created by the large spread between the direct Laspeyres and Paasche indices for time periods that are far apart are compounded by the practical difficulties created by the poor overlap between the sets of products available in the two periods.

Additivity and chaining

16.55. Additivity is a property pertaining to a set of interdependent index numbers related by definition or by accounting constraints. An aggregate is defined as the sum of its components. Additivity requires this identity to be preserved when the values of both an aggregate and its components in some reference period are extrapolated over time using a set of volume index numbers. Although desirable from an accounting viewpoint, additivity is actually a very restrictive property. As already noted, Laspeyres volume indices are additive because extrapolating the base period values by Laspeyres volume indices is equivalent to revaluing quantities in later periods by the same set of base period prices. Additivity implies that, at each level of aggregation, the volume index for an aggregate takes the form of a weighted arithmetic average of the volume indices for its components that uses their base period values as weights. This requirement virtually defines the Laspeyres index. Other volume indices in common use are therefore not additive.

16.56. As already shown, a single link is sufficient to destroy additivity in the linked data expressed in value terms even when additive indices such as Laspeyres volume indices, are linked together. If, therefore, chain volume indices are converted into time series of values by using the indices to extrapolate the values of the base period, components fail to add to aggregates in later periods. For this reason it is common to publish the data only in the form of index numbers. However, this procedure cannot be recommended in general because it may merely conceal the problem from users who may be unaware of the breakdown in additivity and its consequences. Even if they are aware of the non-additivity, they are not able to assess its seriousness for the kinds of analysis on which they may be engaged if the data are published only in index number form. Users may be confused when the index for an aggregate is patently not a weighted arithmetic average of those for its components and may wrongly conclude that there must be errors in the data.

16.57. A perverse form of non-additivity occurs 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. This case cannot be dis-

missed as very improbable. In fact, it may easily occur when the range spanned by the components is very narrow and it has been observed on various occasions. In any case, publishing data only in the form of index numbers and not as values means abandoning any attempt to construct accounts at constant prices.

16.58. When base year values are extrapolated by chain volume indices there are effectively three ways of dealing with the ensuing non-additivity. The first is simply to publish the non-additive "constant price" data as they stand without any adjustment. This method is transparent and indicates to users the extent of the problem. Users may, or may not choose to eliminate the discrepancies for analytical purposes, choosing whatever method they consider most appropriate for their purposes. Some countries prefer to publish unadjusted non-additive data for these reasons. The second possibility is to distribute the discrepancies over the components at each level of aggregation. This is equivalent to methods V and VI in the table. As already explained, this procedure is not without its cost as the volume movements for the components are distorted as a result. For certain types of analysis such distortion could be a serious disadvantage. On balance, it would seem preferable to let users decide whether or not to eliminate the discrepancies so that users mainly interested in volume changes for particular components are not disadvantaged. A third possibility would be to eliminate the discrepancies by building up the values of the aggregates as the sum of the values of the components at each level of aggregation. This procedure cannot be recommended in general. Not only would it introduce distortions into the volume movements of the aggregates but it would also make the results for the aggregates depend quite arbitrarily on the level of disaggregation distinguished within the accounts. By distorting the volume movements for the aggregates this method would appear to defeat the whole objective of trying to obtain improved volume measures at an aggregate level through chaining.

16.59. Similar considerations have to be taken into account when time series of fixed base Laspeyres volume indices and their accompanying constant price series have to be rebased. As noted above, assuming the rebasing is not carried backwards, the linked data for series prior to the new base year will not be additive. For reasons just given, the transparent procedure is simply to publish the non-additive data without adjustment leaving it to users to decide whether, or how to deal with the resulting discrepancies. This does not preclude the possibility that there may be circumstances in which compilers may judge it preferable to eliminate the discrepancies in order to improve the overall reliability of the data.

E. Volume measures for gross value added and GDP

16.60. 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, the goods and services produced and consumed being valued using the same vector of prices: i.e., by:

$$\Sigma pQ - \Sigma pq$$

where the Q's refer to outputs and the q's to intermediate inputs. Value added in year t at current prices is given by:

$$\Sigma p_t Q_t - \Sigma p_t q_t$$

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

$$\Sigma p_o Q_t - \Sigma p_o q_t$$

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.

16.61. Within an integrated set of price and volume measures such as those relating to the flows of goods and services in the use matrix or an input-output table, gross value added has to be measured by double deflation method. Otherwise, it will not be possible to balance uses and resources identically. However, the measurement of gross value added in year t at the prices of some base year is liable to throw into sharp relief some underlying index number problems. Vectors of prices and quantities are not independent of each other. In practice, relative quantities produced or consumed are functions of the relative prices at the time. If relative prices change, relative quantities will be adjusted in response. A process of production which is efficient at one set of prices may not be very efficient at another set of relative prices. If the other set of prices is very different the inefficiency of the process may reveal itself in a very conspicuous form, namely negative gross value added. Even if the revalued gross value added is not actually negative, the gross operating surplus may change from positive to negative, thereby signalling the fact that the production process would not be used at those prices.

16.62. Thus, the measurement of value added using a vector of prices that is very different from that prevailing at the time the production process is carried out may lead to results that are not very acceptable for analytical purposes. In a time series context, this implies that the relative prices of the base year must not be too divergent from those of the current year, so that base years may have to be updated frequently and some form of

chaining used. Chain indices for value added are considered in the next section.

1. Chain indices for value added and GDP

16.63. In order to derive balancing items such as gross value added residually the various elements involved must be additive. Consider the following example:

Let

O_0 = the value of output in period o;

I_0 = the value of intermediate consumption in period o;

C_t = the chain volume index for output in period t;

B_t = the chain volume index for intermediate consumption in period t.

One possibility would be to measure the change in the volume of value added between periods O and t by extrapolating the base period values of both output and intermediate input by the relevant chain indices, as follows:

$$\frac{O_0C_t - I_0B_t}{O_0 - I_0} \tag{20}$$

However, an index such as (20) would have no clear meaning because the chain indices C_t and B_t are not additive. In addition, its behaviour could be unpredictable and erratic, especially if the difference between O_0 and I_0 is small compared with their absolute levels. This method must be rejected on both conceptual and practical grounds.

16.64. When chain indices are used for output and intermediate consumption, an additional chain index must be compiled for value added itself. Suppose chain Laspeyres type volume indices are calculated for output and intermediate consumption. A Laspeyres type chain volume index for value added can then be calculated, each link in the chain being defined as follows:

$$L_q^{VA} = \frac{\Sigma p_{t-1}Q_t - \Sigma p_{t-1}q_t}{\Sigma p_{t-1}Q_{t-1} - \Sigma p_{t-1}q_{t-1}} \tag{21}$$

where the capital letters refer to outputs and the small letters to intermediate inputs. The denominator in (21) is value added in period t-1 while the numerator is obtained by revaluing the outputs and inputs in period t at t-1 prices. Expression (21) can be interpreted as measuring the change in value added between t-1 and t at the prices of t-1. As constant prices are used, the resulting measures are additively consistent.

16.65. A chain volume index for value added can be compiled in this way using Laspeyres type volume indices for each link in the chain. However, in common with all chain indices, it should be noted that the three indices involved—the output index, the input index and the value added index—are not additively consistent among themselves. This can produce counter intuitive and unacceptable results in the long run. For example, for each individual link in the chain it is impossible for the output index to lie outside the range spanned by the intermediate consumption and value added indices. However, because chain indices are not additively consistent, in the long run the chain index for output may drift outside the range spanned by the other two chain indices. Such cases have been observed and documented.

16.66. It is equally possible, of course, to compile a chain volume index for value added using Paasche type volume indices linking successive periods, each link being defined as follows:

$$P_q^{VA} = \frac{\Sigma p_tQ_t - \Sigma p_tq_t}{\Sigma p_tQ_{t-1} - \Sigma p_tq_{t-1}} \tag{22}$$

Each link provides an economically meaningful measure of the volume change in value added by using the prices of period t to value output and intermediate consumption in both periods.

16.67. A third possibility is to compile a chain volume index for value added that uses a Fisher volume index for each link—i.e., the geometric mean of the Laspeyres and Paasche indices given by (21) and (22). Such an index may provide the best volume measure of value added from a theoretical point of view. However, the chain Laspeyres index should provide a very close approximation to the chain Fisher in situations in which it is too difficult or time consuming to calculate the Fisher.

2. Single indicators

16.68. As value added at constant prices is equal to the difference between output at constant prices and intermediate consumption at constant prices it is affected by errors of measurement in both series. Assuming that such errors are at least partly random, the errors will tend to be cumulative, making value added extremely sensitive to error, especially in industries or sectors where value added accounts for only a relatively small proportion of the value of the total output. In some cases, it may be better to abandon the attempt to measure value added as the difference between two series subject to error and to try to estimate the volume movements of value added directly using only one time series—i.e., a "single indicator" instead of double deflation. Although single indicators may be biassed, they are much less sensitive to error. Over the short run the potential bias involved in using single indicators may be negligible compared with the potential errors in the double deflation estimates.

16.69. If there are good data on gross value added at current prices, one alternative to double deflation is to deflate current value added directly by a price index for gross output. This procedure can be described as single deflation. It is likely to yield a close approximation to the change in value added at constant prices, at least in the short run. Another possible procedure is to extrapolate value added in the base year by a volume index for output. This method is likely to yield similar results to the

first method and can be used when data are not available for value added at current prices. The volume index used to extrapolate base year value added can itself be calculated either directly from quantity data or by deflating the current value of output by an appropriate price index. If the data on output at current prices are comprehensive and reliable, the latter method is likely to yield the better estimates.

16.70. The estimation of changes in value added at constant prices by deflating current value added by an output price index or extrapolating base year value added by an output volume index is an acceptable second-best solution when the data available are not sufficiently reliable and robust to permit the use of double deflation. Unfortunately, however, it is sometimes not even possible to obtain satisfactory estimates of price or volume changes for output—for example, in certain market and non-market service industries such as finance, business services, education or defence. In these cases it may be necessary to resort to third-best solutions by estimating movements of value added at constant prices 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 value added at constant prices estimated by means of changes in compensation of employees at constant wage rates, or even simply by changes in numbers employed, in both market and non-market service industries. 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 of value added at constant prices for the construction industry may be estimated from changes in the volume of building materials consumed—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.

3. GDP volume

16.71. Movements in the volume of GDP are always calculated by recalculating the values of the various components of GDP at the constant prices either of the previous year or of some fixed base year. Thus, the volume measure of GDP is frequently referred to as "GDP at constant prices". When time series are constructed by multiplying the values of the base year by fixed base Laspeyres volume indices, it is appropriate to describe the resulting series as being at the constant prices of the base year. However, when the values of the base year are extrapolated by multiplying them by annual chain volume indices it is no longer strictly correct to describe them in this way. This is reflected by the non-additivity of the resulting data. Nevertheless, the series of values are expressed at the general price level of the base year and it is convenient to continue to describe them as being "at constant prices". It is preferable to avoid the term "real GDP" as this may suggest the deflation of GDP by some general price not necessarily that of GDP itself.

16.72. Changes in the volume of GDP for the total economy may be calculated from the expenditure side from data on final expenditures and imports. The double deflation method used to measure gross value added at the level of an industry or sector may be applied at the level of the total economy by replacing output and intermediate consumption by final expenditures and imports.

16.73. The conclusions reached above with regard to the measurement of real value added by industry or sector apply equally at the level of the total economy and may be summarized as follows:

(*a*) The preferred measure of year to year movements of GDP volume is a Fisher volume index; changes over longer periods being obtained by chaining: i.e., by cumulating the year to year movements;

(*b*) The preferred measure of year to year inflation for GDP is, therefore, a Fisher price index; price changes over long periods being obtained by chaining the year to year price movements: the measurement of inflation is accorded equal priority with the volume movements;

(*c*) Chain indices that use Laspeyres volume indices to measure year to year movements in the volume of GDP and Paasche price indices to measure year to year inflation provide acceptable alternatives to Fisher indices;

(*d*) The chain indices for total final expenditures, imports and GDP cannot be additively consistent 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;

(*e*) Chain indices should only be used to measure year-to-year movements and not quarter to quarter movements.

16.74. Two further advantages of using chain indices for GDP may be noted. The quality of the inflation measures is greatly improved compared with the year-to-year movements in the implicit Paasche type deflators calculated on a reference period. A second advantage is that chaining avoids introducing apparent changes in growth or inflation as a result of changing the base year. When the base year for a time series of fixed weight Laspeyres type volume indices is brought forward, the underlying trend rate of growth may appear to slow down if the previous base has become very out of date. This slowing down is difficult to explain to users and may bring the credibility of the measures into question.

4. The publication of alternative volume and price series

16.75. Although the preferred measure of real growth and inflation for GDP is a chain Fisher index, or alternatively a chain

Laspeyres or Paasche index, it must be recognized that the lack of additive consistency can be a serious disadvantage for many types of analysis in which the interrelationships between various flows in the economy are the main focus of interest. Most macroeconometric models fall into this category. It is therefore recommended that disaggregated constant price data should be compiled and published in addition to the chain indices for the main aggregates. The need to publish two sets of data that may appear to conflict with each other should be readily appreciated by analysts engaged in macroeconometric modelling and forecasting. Users whose interests are confined to a few global measures of real growth and inflation can be advised to utilize the chain indices and ignore the more detailed constant price estimates.

16.76. Constant price series have nevertheless to be rebased in the course of time. In general, constant price series should not be allowed to run for more than five, or at the most, ten years without rebasing. It is therefore recommended that disaggregated constant price data should be published for as many of the flows of goods and services in the System as possible, with a change of base year about every five years. When the base year is changed it is customary to link the data on the old base to the data on the new base rather than to carry the rebasing backwards.

16.77. In effect, the underlying issue is not whether to chain or not but how often to rebase. Sooner or later the base year for fixed weight Laspeyres volume indices and their associated constant price series has to be updated because the prices of the base year become increasingly irrelevant. When the base year is updated, series on the old base have to be linked to those on the new base. Thus, sooner or later additivity is lost as a result of linking (assuming the rebasing is not carried backwards). Long runs of data, therefore, almost inevitably involve some form of chain indices. Annual chaining is simply the limiting case in which rebasing is carried out each year instead of every five or ten years.

F. International price and volume indices

16.78. It is possible to compare prices and volumes between countries using the same general methodology as for intertemporal comparisons within a single country. International volume indices are needed in order to compare levels of productivity or standards of living in different countries, while comparisons of prices can be used to measure purchasing power parities between different currencies.

16.79. However, 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*) In time series, it is customary to compare two time periods of the same duration, such as a year. In international comparisons, however, it is not customary to compare areas or regions of equal size. On the contrary, comparisons may be made between economies that are of entirely different orders of magnitude, one perhaps being 10 or 100 times greater than the other. It is as though a volume comparison were to be made between a complete decade and a single year. It is difficult to interpret such data as if they were different points on the same underlying production function. It is also less obvious that two economies of very different sizes should be treated symmetrically;

(*b*) Countries are also modifiable units. They can be disaggregated into smaller units, such as regions, or aggregated into larger blocks such as free trade areas or economic communities. Price and volume measures are needed for blocks as well as individual countries. In these circumstances, the weight attached to the economic activities in a country ought to be invariant to whether the country is considered as a group of regions, a unit in itself or as part of a larger international block;

(*c*) In time series there is continuity between the prices and quantities in successive time periods as the prices and quantities move over time. There is no such continuity between prices and quantities in different countries. In consequence there is no obvious, objective way in which countries can be ordered for purposes of compiling chain indices. Chain indices cannot be expected to play the same role in international comparisons as in intertemporal price and volume measurement.

1. Binary comparisons

16.80. Price and volume indices may be compiled between pairs of countries using the same kinds of index numbers as those used to measure changes between time periods. A Laspeyres type volume index for country B based on country A may be defined as follows:

$$ {}_{a}L_{b}^{q} = \frac{\Sigma v_a \cdot q_b/q_a}{\Sigma v_a} = \frac{\Sigma p_a q_b}{\Sigma p_a q_a} \qquad (23)$$

The fact that the prices in the two countries may be expressed in different currency units is immaterial as only the prices and values in country A are used. The exchange rate between the two countries is irrelevant and plays no part in the comparison. Volume indices such as (23) may be calculated for any flow of goods and services but in practice they have been calculated mainly for total final domestic expenditure and its compo-

nents—household final consumption expenditure, government final consumption expenditure, and gross fixed capital formation. It is, of course, equally possible to utilize the prices and values in country B as weights by defining a Paasche type volume index for B based on A as follows:

$$ {}_{a}P^{q}_{b} = \frac{\Sigma v_b}{\Sigma v_b \cdot q_a/q_b} = \frac{\Sigma p_b q_b}{\Sigma p_b q_a} \qquad (24) $$

16.81. Given the complementary relationships between Laspeyres and Paasche price and volume indices noted earlier, it follows that the Laspeyres volume index for B based on A can be derived indirectly by deflating the ratio of the values in B and A, each expressed in their own currencies, by the Paasche price index for B based on A. This Paasche index is defined as follows:

$$ {}_{a}P^{p}_{b} = \frac{\Sigma v_b}{\Sigma v_b \cdot p_a/p_b} = \frac{\Sigma p_b q_b}{\Sigma p_a q_b} \qquad (25) $$

The individual price relatives, p_a/p_b, that enter into the calculation of (25) are ratios of the prices of the same products in the two countries. It is much less easy to ensure that the same product is being priced in different countries than to collect prices for the same product in different time periods within the same country. By careful specification and identification of products, however, price relatives can be calculated directly from information collected in price surveys in different countries, but there is little doubt that it is more difficult to compile reliable international than intertemporal price relatives.

Purchasing power parities

16.82. In an international index such as (25), the prices in each country are quoted in its own currency units. Each of the individual price relatives p_b/p_a can, therefore, be interpreted as measuring the number of units of B's currency that are needed in B to purchase the same quantity of an individual good or service as 1 unit of A's currency will purchase in A. This ratio is usually described as the purchasing power parity (PPP) between the two currencies for the particular good or service in question. Thus, a weighted harmonic average of the individual PPPs such as (25) is better described as a Paasche type PPP index than a price index. It is, of course, equally possible to calculate the Laspeyres type PPP index for B based on A using the expenditures in country A as weights.

16.83. In practice, PPP indices are mainly used to derive international volume indices by using them to deflate ratios of values in national currencies. They also have considerable intrinsic interest in themselves. They have the same dimensions as exchange rates and may be directly compared with the latter. Dividing a PPP index by the corresponding exchange rate yields a price index that is similar to an intertemporal price index. Such an index shows the average percentage by which the prices of goods and services in country B, when converted into A's currency at the current exchange rate, exceed, or fall below, the prices of the same goods and services in country A. Such information is useful for individuals or institutional units moving from one country to another or engaged in economic activities within both countries. As the PPPs typically relate to domestic final expenditures, they are not designed for the analysis of international flows of goods and services but may still be of considerable interest for the analysis of foreign trade.

16.84. There is a systematic tendency, observed in many empirical investigations, for the domestic price level to be positively correlated with the volume of per capita GDP. As price levels may vary considerably between countries, comparisons of per capita GDP in a common currency using exchange rates must not be interpreted as measuring volume differences only. Such differences in per capita GDP are likely to reflect differences in domestic price levels as well as difference in volumes. Thus, differences in per capita GDP based on exchange rates tend to exceed the differences in the volumes of per capita GDP, especially when comparisons are made between developed and developing countries with very different standards of living.

The spread between Laspeyres and Paasche indices

16.85. Intertemporal price and volume comparisons tend to be confined either to adjacent time periods or to periods that are not very far apart. The differences between the patterns of relative prices and quantities for two different time periods for the same country tend, therefore, to be relatively small compared with those found between different countries, especially between countries with different standards of living, cultures and climates. International price and quantity relatives also tend to be negatively correlated. Institutional units in a country tend to purchase relatively more of goods and services that are relatively cheap in that country compared with other countries. This negative correlation, when combined with substantial differences in the patterns of relative prices, is capable of generating a large spread between the Laspeyres and Paasche indices, both for prices and volumes. For example, the Laspeyres volume index for country B based on country A using A's prices has been observed to be more than twice as large as the corresponding Paasche index using B's prices. Direct quantitative comparisons between economic situations that have little in common with each other are inherently difficult, not only in terms of finding sufficient common data on which to base a meaningful comparison, but also from a conceptual and theoretical viewpoint. Indeed, there may come a point at which it ceases to be useful to attempt such comparisons, although some analysts and policy makers nevertheless may insist on trying to make them.

16.86. Given the existence of such large index number spreads between the Laspeyres and Paasche indices, it is inevitable that some average of the two, such as Fisher's index, should be widely used for international comparisons. Fisher indices ap-

peal particularly to third parties, such as international or supranational organizations, that do not assign priority to the prices or expenditure patterns in either of the two countries.

2. Multilateral comparisons

16.87. The need for multilateral international comparisons may arise for various reasons: for example, when an international organization needs to know the relative sizes of the GDPs of all of its member countries or when aggregates for blocks of countries are needed. Such aggregates can also serve as norms by which the situations of individual member countries can be appraised. In these cases the block constitutes an entity in its own right with its own characteristics. Unique, objective rankings of the volumes of GDP, or per capita GDP, for all the countries in the block require multilateral measures.

Transitivity

16.88. Consider a group of n countries A, B, C, D, etc. 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 $n(n-1)/2$. Let the price, or volume, index number 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:

$$ {}_iI_j \cdot {}_jI_k = {}_iI_k \qquad (26) $$

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. The indirect index is, in fact, the chain index connecting k and i using j as the link country. 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 indices in common use—such as Laspeyres, Paasche or Fisher—is transitive.

16.89. Transitivity is not important in a time series context because time periods form an ordered sequence. For this reason, there is little interest in direct comparisons between all possible pairs of time periods. Direct comparisons tend to be confined either to comparisons with a selected base period, typically the first period in the sequence (leading to fixed base Laspeyres or Paasche indices) or to comparisons between consecutive time periods (leading to chain indices). Comparisons between other possible pairs of periods are not usually needed or undertaken.

16.90. However, no one country in a group of countries has the same status as the first period in a time series. There is usually no good economic reason why one particular country should be singled out to assume the role of base country. Moreover, the choice of base can be much more critical in an international context as patterns of relative prices and quantities are capable of differing much more between countries than between successive time periods within the same country. In general, the use of a single country as base country is not likely to be acceptable to users when the results are so sensitive to the subjective choice of the country to act as base.

16.91. 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 either to all countries or to all economic activities wherever they take place. There are two quite different approaches that may be used. The first achieves transitivity by using the average prices within the block to calculate the multilateral volume indices. The second starts from the binary comparisons between all possible pairs of countries and transforms them in such a way as to impose transitivity.

The block approach

16.92. The block approach assigns priority to the economic characteristics of the block as a whole. The most widely used method in this category is one in which the average prices of the block are used to revalue quantities in all countries in the block. This automatically ensures transitivity. The volume index for country B relative to country A is therefore defined as:

$$ {}_aGK_b = \frac{\Sigma \bar{p} q_b}{\Sigma \bar{p} q_a} \qquad (27) $$

The average price $\bar{p}$ for each individual good or service is defined in the normal way as its total value in the block, expressed in some common currency, divided by its total quantity:

$$ \bar{p} = \frac{\sum_j c_j p_j q_j}{\sum_j q_j} \qquad (28) $$

where the summation is over the different countries in the block. The term c_j in expression (28) is a currency convertor, that could be either a market exchange rate or a PPP, that is used to convert each $p_j q_j$ into the common currency. In the limit, the block consists of all countries in the world. The use of average world prices has certain attractions, including simplicity and transparency, both from an economic and a statistical viewpoint. The use of world prices ensures that volume comparisons are not affected by the way in which blocks of countries are defined, by the subsequent inclusion or exclusion of countries from a particular block, or by the way in which countries may be grouped hierarchically to form regional blocks. It facilitates the aggregation of data for different countries that make up regional blocks and comparisons between the aggregate data for such blocks.

16.93. The most common block method is the Geary Khamis (GK) method in which the currency convertors used in (28) are the

PPPs implied by the volume indices defined by (27). 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. The first step is to use exchange rates as currency convertors to calculate an initial set of average prices and then to use the resulting volume indices to derive the implied set of PPPs. The latter are then used to calculate a second set of average prices, volume indices and PPPs, etc. This iterative process converges quickly. Alternatively, the PPPs and average prices can be obtained directly by solving the underlying set of simultaneous equations.

16.94. The average prices defined by (28) play the same role in international comparisons as the constant prices of the base period play in a time series of Laspeyres volume indices on a fixed base. The use of constant prices ensures that the resulting volume indices between all pairs of countries must be transitive: clearly,

$$\frac{\Sigma\bar{p}q_k}{\Sigma\bar{p}q_i} = \frac{\Sigma\bar{p}q_j}{\Sigma\bar{p}q_i} \cdot \frac{\Sigma\bar{p}q_k}{\Sigma\bar{p}q_j} \qquad (29)$$

whatever average prices are used.

16.95. A block method such as the GK method has the following advantages:

(*a*) The block of countries is recognized as an entity in itself with its own vector of relative prices that is used for volume measurements within the block;

(*b*) The use of a single vector of prices ensures that the resulting volume measures, and associated implicit PPPs, are all transitive;

(*c*) The volume measures are additively consistent and can be presented in value terms using the average prices of the block expressed in the common currency in a user friendly way;

(*d*) Because the same vector of prices is used for all countries, it is possible to compare the relative amounts of resources allocated for different purposes in different countries, such as the shares of GDP devoted to gross fixed capital formation, or to expenditures on health, education or research and development.

16.96. On the other hand it can be argued that the volume comparisons for individual aggregates are not all optimal. The difficulty is that relative prices and quantities in some countries are bound to diverge more than others from the averages for the block as a whole. Suppose country A's relative prices are close to the average for the block while country B's diverge because B is atypical. Country B might, for example, be relatively rich or relatively poor compared with the rest of the block. When the average prices for the block are used, the volume index for B on A is likely to be close to a Laspeyres index based on A and, therefore, greater than a symmetric binary index, such as Fisher's index. This may be considered a disadvantage for the two countries considered in isolation although it cannot be assumed that symmetric binary measures are optimal in a multilateral context. The fact that symmetric binary measures are intransitive shows that they are mutually inconsistent from the point of view of the block as a whole.

The binary approach

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

16.98. Fisher indices are not transitive but it is possible to derive from them a set of n-1 transitive indices that resemble the original Fisher indices as closely as possible, using the traditional criterion of least squares for this purpose. Minimizing the deviations between the original Fisher indices and the desired transitive indices leads to the so-called EKS formula proposed independently by Eltetes, Kovecs and Sculz.

16.99. The EKS index utilizes all the indirect indices linking country i and country k as well as the direct index between them. The indirect volume index between i and k via country j is a chain index that uses country j as the link country: that is, if ${}_iF_j$ is the Fisher volume index between countries i and j, the indirect index between i and k that uses j as the link is then the index ${}_iF_j \cdot {}_jF_k$. The EKS 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 EKS index for any given pair of countries.

16.100. The EKS index is notadditively consistent. The consequences are similar to those for chain indices in a time series context. It is not possible to convert the EKS volume indices for an aggregate and its components into a set of values, expressed in a common currency, in such a way that the values of the components of some aggregate add up to the value of that aggregate. Thus, in contrast to the GK method, it is not possible to present the results for a group of countries in the form of a table with countries in the columns and the various final expenditure components in the rows, in which the values add up in the columns as well as across the rows.

16.101. As in the analogous time series case, the discrepancies between the values of the aggregates and the sums of their components could be eliminated in mechanical ways either by distributing the discrepancies over the various components or by defining aggregates as the sums of their components. However, as already explained, such methods distort the comparisons between pairs of countries either for the components or for the aggregates, whichever method is adopted.

The publication of alternative volume and price measures

16.102. The GK and the EKS methods have the same kind of advantages and disadvantages as fixed price volume indices and chain volume indices in a time series context. The EKS index may provide 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. However, lack of additive consistency is a disadvantage when comparing interrelated aggregates for several countries within an accounting framework: for example, analyses that require information on the relative shares of resources devoted to particular purposes in different countries or analyses that involve differences in relative prices. The GK method is better suited to structural analyses of this kind. It enables individual types of expenditures to be summed across all the countries to obtain aggregates for the block exactly as if the different countries were simply different regions within a country. The GK method recognizes the block as an entity in itself and utilizes its characteristics for measurements within the block. On the other hand, the EKS method adopts an atomistic approach by treating the countries themselves as independent entities whose relative sizes are first determined by comparing each country with each other country and then seeks to disturb these measures as little as possible when transforming them into a set of transitive measures.

16.103. In general, the methods used to compile statistics must be influenced by the purposes for which they are to be used. As in the case of time series of national accounts, it is therefore suggested that two sets of data should be compiled and published:

(*a*) EKS indices should be compiled for GDP and the main expenditure aggregates—household final consumption expenditures, government final consumption expenditures and gross capital formation. These would consist of both volume and PPP indices. The EKS indices are most useful for purposes of comparing individual aggregates taken in isolation, such as GDP or total household consumption;

(*b*) GK results should also be published in the form of values at the average prices of the block of countries expressed in some common currency such as the US dollar. As these data are additively consistent, they can be published in full detail for the benefit of users interested in interrelationships between components and aggregates. Such data are needed for structural analyses involving ratios and shares.

16.104. These conclusions are similar to those reached for intertemporal comparisons. In both cases, the best measures for individual aggregates, such as GDP, taken in isolation are provided by indices that are not additive—chain indices in a time series context and EKS indices in an international context. As sets of additive data are also needed for modelling and analytical work, it is also necessary to provide data in the form of values at constant prices—either at the prices of some base period or at the average prices of a block of countries.

G. The treatment of differences and changes in quality

1. Quality differences, price variation and price discrimination

16.105. 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 prepacked, graded or ungraded, etc. Unwashed, loose, old red potatoes are clearly different qualities of potatoes from washed, prepacked, new white potatoes. Consumers recognize and appreciate the differences and are prepared to pay different prices.

16.106. The expression "different qualities" is used to cover sets of goods or services whose characteristics are sufficiently different to make them distinguishable from each other from an economic point of view but which are sufficiently similar to each other to be described by the same generic term, such as potato, computer or transportation. Different prices are charged for different qualities of the same kinds of goods or services in much the same way that different prices are charged for goods or services which are generically different from each other and described by different names. Different qualities have to be treated in exactly the same way as different kinds of goods or services.

16.107. Differences in quality that are attributable to differences in the physical characteristics of the goods or services concerned are easily recognized, but not all differences in quality are of this kind. There are other factors which can give rise to differences in quality. For example, goods or services delivered in different locations, or at different times, must be treated as different qualities even if they are otherwise physically identical. These differences stem from the fact that the marginal utility of a particular kind of good or service for purchasers or consumers situated in one location may be very different from that for purchasers in other locations, while the costs of delivering goods or services in different locations also vary. Transporting a good to a location in which it is in greater demand is a process of production in its own right in which the good is transformed into a higher quality good.

16.108. Similarly, goods or services provided at different times of the day or at different periods of the year must be treated as differ-

ent qualities even if they are otherwise identical. For example, electricity or transport provided at peak times must be treated as being of higher quality than the same amount of electricity or transport provided at off-peak times. The fact that peaks exist shows that purchasers or users attach greater utility to the services at these times, while the marginal costs of production are usually higher at peak times. The different prices or rates charged at peak and off-peak times provide measures of these differences in quality. Similarly, fruit and vegetables supplied out of season must be treated as higher qualities than the same fruit and vegetables in season which are cheaper to produce and of which consumers may be satiated.

16.109. Apart from differences in location or timing there are other factors which may contribute to quality differences. For example, 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. A restaurant meal provided with more attentive service in more luxurious or pleasant surroundings is a higher quality meal than exactly the same food and drink provided with less service in a less pleasant environment. A durable good sold with a guarantee, or free after-sales service, is higher quality than the same good sold without guarantee or service. Thus, 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 for these kinds of reasons. Alternatively, the goods may be envisaged as being parts of different composite products which incorporate different amounts, or kinds, of retail services. Purchasers in large supermarkets may have to find, select and transport their own purchases to check-outs, but they are also offered the advantage of greater choice and the opportunity to reduce the amount of time spent shopping by making purchases in bulk. All these kinds of factors introduce qualitative differences.

16.110. In general, therefore, it is necessary to pay attention to differences in the situation, or conditions, in which goods and services are supplied, as prima facie these may all be expected to introduce qualitative differences into the goods or services supplied. In economic theory it is generally assumed that whenever a difference in price is found between two goods and services which appear to be physically identical there must be some other factor, such as location, timing, conditions of sale, etc., which 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. In most cases, therefore, differences in prices at the same moment of time must be taken as prima facie evidence that the goods or services concerned represent different qualities of the same general kind of good or service. As explained in the first section of this chapter, this implies that if there is a switch towards higher priced—i.e., higher quality—goods or services, this will be recorded as an increase in volume and not price.

16.111. 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.

16.112. First, 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 out 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 on expenditures, 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.

16.113. 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; i.e., 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.

16.114. 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—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.

16.115. For the three reasons just given, i.e., 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.

16.116. 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.

16.117. 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.

2. Changes in quality over time

16.118. 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. In principle, the price relatives that enter into the calculation of intertemporal price indices should measure pure price changes by comparing the prices of identical goods and services in different time periods. If the qualities of goods or services being compared are not identical, there are effectively four options:

(*a*) To ignore the change in quality and compile a price relative as if no difference in quality existed;

(*b*) To omit the items in question and not compile a price relative for them;

(*c*) To adjust the observed price of the new quality for the change in quality which has taken place;

(*d*) To treat the two qualities as if they were two separate goods and to estimate their prices in the periods in which they are not sold.

16.119. The first option should be avoided. Ignoring changes in quality is likely to introduce serious biases of unknown size, or even direction, into the measured price or volume indices. The second option is also not to be recommended. It will also tend to introduce bias. If goods or services are omitted from the calculation of price indices that are intended to be comprehensive in coverage, their omission is equivalent to assuming that their rate of price change is the same as the average for the items covered by the indices. However, 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 highly questionable.

16.120. The third and fourth options are clearly to be preferred although they are not always easy to implement in practice. Some methods that may be employed are explained in the following paragraphs.

16.121. The adjustment for quality change may be based on the relative prices of the two qualities on the market when there is at least one period when both qualities are on sale on the market at the same time. Suppose, for example, that one quality is replaced by another as follows:

Period	Old quality	New quality
0	p_0	
t	p_t	p_t^*
n		p_n^*

In period 0, only the old quality is available while in period n only the new quality is available. If both are available simultaneously in some intervening period t, the ratio of their relative prices in period t, namely p_t/p_t^*, may be used as a measure

of the relative volumes of the old and the new qualities. Thus, the price relative connecting the new quality in period n with the old quality in period 0, after adjusting for the difference in their qualities, is given by:

$$p_n^*(p_t/p_t^*)/p_o$$

This is equivalent to constructing a price relative connecting p_n^* with p_o by splicing the price change for the new quality to the price change for the old quality, using period t as the link period: that is,

$$(p_n^*/p_t^*)(p_t/p_o)$$

16.122. This procedure may be used to deal with quality changes in all those cases in which the new and the old qualities overlap on the market for a significant amount of time. If the relative prices of the two qualities do not remain constant during this time, some kind of average of their relative prices may be used to estimate their relative qualities.

16.123. 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. Producers of many kinds of durable goods, such as automobiles, deliberately stop producing the old model when the new model is introduced on the market. Such producers typically vary the characteristics of their product—size, performance, style, etc.—in order to stimulate demand without changing the general nature of the product or the purposes for which it is used. 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 as measures of the relative qualities.

16.124. One possibility is to use the estimated relative costs of production as estimates of their relative prices and hence their relative qualities. It may often be feasible for producers to provide such estimates, The observed change in price between the old and the new qualities may then be adjusted as follows. Suppose the price of the new quality or model is x per cent higher than the price of the old, while it is estimated that the new quality would cost y per cent more to produce than the old, then the price relative connecting the old and new qualities, adjusted for the change in their qualities, is equal to

$$\frac{100+x}{100+y}$$

16.125. 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, instead of trying to compare the prices of actual buildings or structures in one period with those of other, possibly not very similar, buildings or structures in another period, it may be better to specify a small number of hypothetical and relatively simple standard buildings and structures and to estimate what their prices would be 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. Alternatively, the experts can be asked to estimate the costs of construction in both periods, the price relatives being assumed to be equal to the ratios of the construction costs. Construction experts are frequently asked to make such estimates in practice. This method has been used successfully to make international comparisons of the prices of buildings and structures as well as for estimating price changes over time.

The use of the hedonic hypothesis

16.126. A more general and powerful method of dealing with changes in quality is to make use of the so-called "hedonic" hypothesis to estimate the prices of qualities or models that are not available on the market in particular periods, but whose prices in those periods are needed in order to be able to construct price relatives. The hedonic hypothesis assumes that the prices of different models on sale on the market at the same time are functions of certain measurable characteristics such as size, weight, power, speed, etc. Provided there are enough observations—i.e., provided enough different models are on sale at the same time—regression methods can be used to estimate by how much price varies in relation to each of the characteristics. The resulting regression coefficients can be used to predict the prices of models with different mixes of characteristics that are not actually on sale in the period in question.

16.127. Suppose, for purposes of argument, that the price of a model is a function of only one characteristic such as size. Suppose further, that the following sizes are on sale in two different periods of time:

Period 0	Period t
s_1	
s_2	
	s_3
s_4	
	s_5
	s_6

By calculating the regression of price on size in each period, it should be possible to obtain a reliable estimate of the price of s_3 in period 0 and s_4 in period t, thus enabling at least two price relatives to be calculated connecting periods 0 and t. Furthermore, if it is deemed legitimate to make estimates outside the range spanned by the observations in each of the periods, it may be possible to estimate prices for sizes s_5 and s_6 in period o, and for sizes s_1 and s_2 in period t, thereby enabling price relatives to be calculated for all six sizes. The validity of making estimates outside the range of observations cannot be settled a priori: it depends on the nature of the data and the form of the relationship. If the underlying functional form is the

same in both periods it may be possible to pool the two sets of observations to obtain improved estimates of the price coefficient, using a dummy variable to distinguish observations in one period from those in the other. Similarly, the choice of functional form—linear, log-linear, log-log, etc.—must be settled empirically, case by case. In general, the choice of appropriate statistical technique has to depend on the nature of the data set in each case.

16.128. The hedonic hypothesis has been used with some success to deal with changes in the quality of computers over time. The quality of a computer depends mainly on two basic characteristics: its capacity and its speed of operation. Regressions of prices on those two characteristics have made it possible to estimate the prices of models in periods in which they were not actually on sale. For example, new models are continually being produced with much greater capacities and speeds than were available in earlier periods. By using regression methods, however, it becomes possible to estimate what their prices would have been if they had been produced in earlier periods, thereby enabling price relatives to be estimated that refer to the same kinds of models in different time periods. By using such methods, it has been shown that the price of a computer of unchanged quality—i.e., with a given capacity and speed—tended to fall dramatically during the 1970s and 1980s.

16.129. The hedonic hypothesis may be used for any goods or services whose prices depend mainly on a few basic characteristics and for which sufficient numbers of different models, or qualities, are on sale on the market at the same time. In addition to computers it may be used for other high technology goods whose characteristics are both measurable and varying significantly over time. It has also been used for housing by regressing house prices (or rents) on characteristics such as area of floor space, number of rooms, location, etc. The method has been used not only for intertemporal price measurements but also international comparisons.

H. Choice between direct and indirect measurement of prices and volumes

16.130. When independent, reliable and comprehensive data are available at current prices it is not necessary to calculate both the price and the volume measures as one can be derived indirectly from the other as explained above. In most cases it is better to calculate the price index directly and to derive the volume index indirectly.

16.131. There are two reasons for this: first, it is usually necessary to estimate the average price or volume change from a selection, or sample, of goods and services, and price relatives tend to have a smaller variance than the corresponding quantity relatives. Thus, the sampling error for a price index tends to be smaller than for a volume index. Secondly, the volume changes associated with new and disappearing products are properly reflected when current values are deflated by price indices. Suppose, for example, that there are some new products which are sold in the later period but not the base period; their quantities are known in both periods (being zero in the base period), whereas their prices are known for only one period, the later period. This quantity information is incorporated in the current value series and is also automatically incorporated in the volume series when the latter is obtained by deflating the current value series. This may be illustrated by a simple numerical example:

Good	P_0	Q_0	P_1	Q_1
1	4	10	6	12
2	-	-	5	2
Current value	40		82	

Good 2 is a new good not on the market in period 0. The price and quantity relatives for good 1 are 150 and 120 respectively, while for good 2, the price relative is unknown whereas the quantity relative is plus infinity. This information must be utilized. The best estimate of the price index for both goods is 150, based on good 1 alone. If this is used to deflate the value index covering both goods the derived volume index is

$$\frac{82/40}{1.5} = 1.367$$

This volume index exceeds the quantity relative for good 1 alone because the increase in the quantity of good 2 incorporated in the current value series has been taken into account.

16.132. The above argument rests on the tacit assumption that the values at current prices are obtained from different sources from the price and quantity data and are reliable and comprehensive. However, it may happen that the movements of the series at current prices have been estimated by multiplying together the estimated price and volume movements. Alternatively, estimates of the current values—for example, values of agricultural output—may be made by multiplying estimates of the

quantities by estimates of their prices, and not by collecting separate information on the values of goods produced. In such cases the deflation of current values merely leads back to the original quantity estimates.

I. Non-market goods and services

16.133. The value of the output of non-market goods and services produced by government units or non-profit institutions is estimated on the basis of the total costs incurred in their production, as explained in chapter VI. This output consists of individual goods and services delivered to households as social transfers in-kind or collective services provided to the community as a whole. The fact that such output is valued on the basis of the value of the inputs needed to produce them does not mean that it cannot be physically distinguished from the inputs used to produce it. Nor does it imply that changes in such output over time cannot be distinguished from changes in the inputs. Changes in productivity may occur in all fields of production, including the production of non-market services.

16.134. In principle, volume indices may always be compiled directly by calculating a weighted average of the quantity relatives for the various goods or services produced as outputs using the values of these goods and services as weights. Exactly the same method may be applied even when the output values have been estimated on the basis of their costs of production.

16.135. Of course, the calculation of quantity relatives for the outputs of many kinds of non-market services, especially collective services, presents problems. In the case of health and education services provided as social transfers to individual households, however, the problems are much less, both conceptually and in practice, than for collective services such as public administration or defence. The objective is to measure the quantities of services actually delivered to households. These should not be confused with the benefits or utility derived from those services. For example, individual health services consist of various kinds of consultations and treatments provided to patients, which can be described and documented in considerable detail. Detailed records of such services frequently exist for administrative purposes.

16.136. The output of health services needs to be clearly distinguished from the health of the community. Indeed, one reason for trying to measure the output of health services may be to see the effect of an increase in the volume of health services on the health of the community. This obviously requires a measure of the volume of health services that is different from health itself. It is well-known that there are many other factors such as sanitation, housing, nutrition, education, consumption of tobacco, alcohol and drugs, pollution, etc., whose collective impact on the health of the community may be far greater than that of the provision of health services.

16.137. 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 producers of education services—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. As in the case of other types of output, when compiling indicators of the output of educational services it is important to distinguish as many different kinds of education service as possible as their relative costs, or qualities, may vary considerably. Moreover, the quality of education services provided may vary over time in the same way as other goods and services. The quality of education services is likely to depend on the amount of resources provided per pupil or student: for example, the numbers of teachers or amount of capital equipment in the form of laboratories, libraries, computers, etc.

16.138. There is no mystique about non-market health or education services which make changes in their volume more difficult to measure than volume changes for other types of output, such as financial or business services or fixed tangible assets. Moreover, changes in their volume are also needed in order to be able to measure volume changes for the actual consumption of households. The same principles apply to the measurement of consumption as to production.

16.139. Measuring changes in the volume of collective services is distinctly more difficult, however, as it is not possible to observe and record the delivery of such services. Many collective services are preventive 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. It is difficult to measure the output of preventive services, and this is an area in which further research is needed. In practice, it may not be feasible to avoid using changes in the volumes of inputs into such services as proxies for changes in volumes of outputs, just as it may sometimes be necessary to use changes in inputs as proxies for changes in outputs in certain market industries, such as agriculture or construction.

16.140. 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 and not confined to labour inputs. As explained below, the volume of labour inputs can be measured by compensation of employees valued at the wage and salary rates of the previous year or some fixed base year, the remuneration of each individual type of worker being revalued at the appropriate rate. The volumes of intermediate consump-

tion, consumption of fixed capital and any taxes on production measured at the prices or rates of the previous year or the fixed base year should be added to obtain a comprehensive volume measure covering all inputs. These volume measures can, of course, also be derived by deflating the current values by suitably weighted wage rate, price or tax rate indices.

16.141. A possible alternative method when input measures are used as proxies for outputs is to use a volume measure for labour alone combined with an explicit assumption about changes in labour productivity; for example, that labour productivity grows at 1 per cent per year in the production of the non-market service in question. An assumption of zero productivity growth is the most common one in practice because it is felt to be more neutral, even though it is inevitably somewhat arbitrary. The attention of users should always be drawn to any built-in assumption about the rate of growth of labour productivity which should be stated explicitly, even when it is zero.

J. Scope of price of volume measures in the System

16.142. 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 a few other flows directly into their own price and volume components, the most important of which is compensation of employees.

1. Compensation of employees

16.143. The quantity unit for compensation of employees may be considered to be an hour's work of a given type and level of skill. 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, of course, between different types of work. A volume measure of work done may be calculated as a weighted average of the quantity relatives for different kinds of work weighted by the values of compensation of employees in the previous year or 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 compensation of employees as weights. If a Laspeyres type volume index is calculated indirectly by deflating the changes in compensation of employees at current values by an index of the average change in hourly rates of compensation, the latter should be a Paasche type index.

2. Consumption of fixed capital

16.144. Another cost of production and charge against gross value added, namely consumption of fixed capital, may also be measured at the prices of the previous year or some fixed base year. Indeed, when estimates of the gross and net capital stocks are compiled using the perpetual inventory method, an estimate of consumption of fixed capital at the constant prices of some base year is already built into such calculations.

3. Taxes and subsidies on products

16.145. It is also possible to factor taxes or subsidies on products into their own price and volume components because the quantity units on the basis of which such taxes or subsidies are payable can also be used as quantity units to define "tax prices". A tax price is the amount of tax payable per unit of good or service, whether the tax is payable per unit of quantity or *ad valorem*. The tax prices can be used to construct tax price relatives which can then be averaged to obtain "tax price indices" using the values of the amounts paid in tax as weights. A "tax volume index" can be derived indirectly by deflating changes in the total amounts of taxes paid by the appropriate version of the tax price index. A tax volume index is essentially a volume index for a flow of goods and services in which the relative importance of the goods and services is measured not by their relative market prices but the relative amounts of tax paid per product. It shows by how much the receipts from taxes on products change purely in response to changes in the volumes of goods and services subject to tax. Factoring tax receipts into price and volume components may be useful for purposes of fiscal analysis and may also be useful in the context of the input-output table.

4. Net operating surplus

16.146. The net operating surplus is an accounting residual which does not possess quantity and price dimensions of its own. It may also be negative, of course. It is not possible, therefore, to decompose the net operating surplus into its own price and volume components. It is therefore also not possible to calculate the average volume change for all the uses of gross value added shown in the generation of income account.

16.147. Thus, the limit to a set of integrated price and volume measures within the accounting framework of the System is effectively reached with the net operating surplus. It is conceptually impossible to factor all the flows in the income accounts of the System, including current transfers, into their own price and volume components. Of course, 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 as explained at the beginning of this chapter, this is quite different from decomposing a flow into its own price and volume components.

K. Measures of real income for the total economy

1. Introduction

16.148. It is possible to deflate any income flow in the accounts, and even a balancing item such as saving, 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 real purchasing power of the income has increased or decreased. Income deflated in this way is generally described as "real income".

16.149. In interpreting real incomes two points need to be borne in mind:

(*a*) Real incomes are measured with reference to the price level in some selected reference year. Real values cannot exist in isolation: they vary depending upon the choice of reference year;

(*b*) Real incomes measure changes in purchasing power over some selected numeraire; they thus also depend upon the choice of numeraire.

16.150. 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 multi-purpose 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

16.151. Before considering the various different real income aggregates which may be defined for the total economy, it is necessary to explain the fundamental difference between gross domestic product at constant prices, and real gross domestic income, or real GDI. GDP at constant prices is essentially an output volume measure. It may be calculated at the level of the total economy by a form of double deflation in which imports valued at the basic prices of the previous year, or some fixed base year, are subtracted from total final expenditures valued at the purchasers' prices of the previous year, or the fixed base year. A measure of this kind is essentially a volume measure of the output from domestic production, even though it includes taxes on imports and possibly some other taxes on products that are excluded from the gross values added of resident producers.

16.152. However, the total real income which residents derive from domestic production depends also on the rate at which exports may be traded against imports from the rest of the world. If the prices of a country's exports rise faster (or fall more slowly) than the prices of its imports—i.e., if its terms of trade improve—less 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. Real GDI measures the purchasing power of the total incomes generated by domestic production so that when the terms of trade change there may be a significant divergence between the movements of GDP at constant prices and real GDI. The difference between the change in GDP at constant prices and real GDI is generally described as the "trading gain" (or loss). The differences between movements in GDP at constant prices 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 which make up imports and exports are 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. It can easily be shown that trading gains or losses, T, are measured by the following expression:

$$T = \frac{X - M}{P} - \left(\frac{X}{P_x} - \frac{M}{P_m} \right) \qquad (30)$$

where

X = exports at current prices

M = imports at current prices

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 to 1 in the base year. It can be seen that 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.

16.153. There is one important choice to be made in the measurement of trading gains or losses, i.e., 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.

16.154. 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 what are the main alternatives which 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.

16.155. 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 in equation (30) above, should be treated as an integral part of the System;

(*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.)

16.156. 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. In those circumstances in which there is uncertainty about the choice of deflator an average of the import and the export price indices is likely to provide a suitable deflator.

3. The interrelationship between volume measures and real income aggregates

16.157. Assuming that measures of trading gains or losses are available, various different real income aggregates may be identified within the System. The links between them are displayed in the following list:

(*a*) *Gross domestic product at constant prices*: i.e., GDP in the current year valued at the prices, or price level, of the base year obtained by extrapolating (i.e., multiplying) the value of GDP in the base year by the volume index for GDP, whether a fixed weight or a chain index;

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

(*b*) equals: *real gross domestic income*;

plus real primary incomes receivable from abroad

minus real primary 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 consumption of fixed capital at constant prices;

(*e*) equals: *real net national disposable income.*

16.158. In the above accounting scheme, each aggregate is derived sequentially starting from gross domestic product at constant prices, the volume measure of GDP. The transition from (a) to (b) above has been explained in the previous section. 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, primary incomes and current transfers received from abroad and paid 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, namely the set of goods and services that make up gross domestic final expenditure. In other words, primary incomes and current transfers should both be deflated by a price index for gross domestic final expenditures. This price index should, of course, be defined consistently with the volume and price indices for GDP.

16.159. A possible alternative which could be considered is to use the following accounting framework:

(*a*) *Gross domestic product at constant prices* as defined above

plus imports at constant prices

minus exports at constant prices;

(*b*) equals: *gross domestic final expenditures at constant prices*, i.e., final consumption expenditure plus gross capital formation at constant prices

less consumption of fixed capital at constant prices;

(*c*) equals: *net domestic final expenditures at constant prices*

plus net current receipts from abroad measured in real terms (i.e., deflated by the price index for net domestic final expenditure), namely:

(*i*) Deflated value of the current trade balance (exports *minus* imports);

plus (*ii*) Deflated values of primary incomes receivable *minus* primary incomes payable abroad;

plus (*iii*) Deflated value of current transfers receivable *minus* current transfers payable abroad;

(*d*) equals: *real net national disposable income*.

16.160. In this framework, all current flows to and from abroad are deflated by a single deflator, that for item (c), i.e., net domestic final expenditures. In effect, this index acts as a general price deflator for all items from row (c) onwards. If there are no satisfactory estimates available for consumption of fixed capital at constant prices so that all expenditure measures have to remain gross, the price index for gross domestic final expenditures may be used instead.

16.161. This alternative framework has the advantage that the various components of real income are all measured with reference to a single numeraire, the set of goods making up net domestic final expenditures. It is easier, therefore, to grasp the significance of real net national disposable income as its deflator is explicit. The alternative framework measures the trading gain or loss by using the deflator for net domestic final expenditures as the general deflator P, whereas it can be argued that P ought always to be based on flows which enter into foreign trade. There is, for example, a possibility that the implicit trading gain may be negative when there is a positive change in the terms of trade, or vice versa, and this may be considered a serious disadvantage. On balance, therefore, the original framework presented above is to be preferred. However, the guidelines laid down by the System need to be somewhat more tolerant in the domain of real income measurement than elsewhere, and the use of alternative deflators, for what may be considered to be good statistical or economic reasons, is by no means incompatible with the basic philosophy underlying the System, which in certain other fields also (e.g., sub-sectoring the households sector) needs to be implemented flexibly and not rigidly.