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INTERNATIONAL COMPARISONS OF REAL PRODUCT: AN APPROACH BY INDUSTRY OF ORIGIN

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I. INTRODUCTION

THE methods used in international comparisons of the real product do not differ in principle from those used to deflate national income estimates over time. The same problems have to be dealt with, but they are somewhat more intractable over space because differences in industrial and institutional pattern existing even between two countries of very similar social structure and standard of living are far greater than will normally be encountered over time. The difference is, however, largely one of degree, and the problem can be compared to that of an intertemporal deflation over a long period, or of bridging a period of profound change in institutions, technique and consumption pattern.

As in intertemporal comparisons the problem can be approached from the expenditure side of the social accounts, or by industry of origin. The greater part of the work done in this field so far has been based on the final expenditure approach, but it is certainly worth considering how far the industry of origin approach can be used to supplement the other. There are many analytical purposes for which the industry of origin classification is the more suitable. Relative productivity and comparative costs may be mentioned as examples of two fields in which valuable work has been done,[1] and which might benefit greatly from a comprehensive estimate of relative real product in the industry of origin classification.

The difficulties and limitations of this approach must not be underestimated. Since the final bill of goods is the same on both sides of the account, problems of measurement and non-comparability encountered in the comparison of final expenditure cannot be completely avoided by approaching the problem from the other side of the accounts. Moreover, even where the same items are included in final consumption, methods of manufacture may differ considerably, both in

[1] See L. Rostas, *Comparative Productivity in British and American Industry*, Cambridge University Press, 1948, and G. D. A. MacDougall, 'British and American Exports; a study suggested by the theory of comparative costs', *Economic Journal*, December 1951 and September 1952.

technique and in industrial organization, and goods consumed in both countries may be produced in only one of them and imported by the other.

From a practical standpoint the industry of origin approach has two important advantages which may outweigh these difficulties. Firstly, a substantial proportion of the aggregate weight is allocated to the basic intermediate products, such as iron, steel, textile yarns and staple agricultural products, which, owing to greater standardization, are more easily measured in physical units with a far greater accuracy than the corresponding final products, machinery, vehicles, clothing, processed foodstuffs, etc. Only a small proportion of these basic products enter into final output, a large part of which consists of products which can only be measured by rather crude quantity indicators, or by value series with price deflators based on relatively small samples. In the industry of origin approach these cruder indicators are only required to measure the value added by manufacture in the final stages. Thus less weight is given to the more vulnerable sections of the comparison. Certain quality variations are also more easily measured in the intermediate stage, e.g., a larger relative output of pure wool yarns indicates heavier cloths and a larger proportion of woollen knitted goods, high-grade steel indicates higher quality cutlery, etc.

The second practical advantage is that for most modern industrial countries a large part of the field is covered in the census of production. This not only facilitates work, but ensures that prices, quantities and values are available from a source that is internally consistent, an important factor in minimizing the margin of error. When such a source is not available, and it is necessary, for example, to arrive at a volume index by deflating expenditure estimates by an independent sample price index, there is considerable risk of large cumulative errors resulting from errors in opposite directions in the two components.

This paper discusses the methodology of the industry of origin approach to international comparisons of final output at factor cost.[1] Use has been made of experience gained in a pilot

[1] For the application of the industry of origin approach to intertemporal comparisons, see W. B. Reddaway, 'Some Problems in the Measurement of Changes in the Real Geographical Product', *Income and Wealth, Series I* (1951), and 'Movements in the Real Product of the United Kingdom, 1946–1949', *Journal of the Royal Statistical Society*, Pt. IV, 1951; extensive use has been made of both these articles.

study, still in its initial stages, comparing the real product of the United States and the United Kingdom, largely on the basis of the United States 1947 Census of Manufactures and the United Kingdom 1948 Census of Production. Attention is, however, given to all the main sectors of the gross national product, although some of these are only touched upon. This has been done in order to try and show that comprehensive empirical work on this side of the accounts can be undertaken in sufficient detail and on sufficiently realistic assumptions to make the results useful for analysis.

II. GENERAL METHOD

The method used is a simple adaptation of the Laspeyres/Paasche formulae. If X and Y are the two countries and the results are to express X's product in terms of Y's, these formulae will then be

$$\frac{\Sigma P_y Q_x}{\Sigma P_y Q_y} \text{ and } \frac{\Sigma P_x Q_x}{\Sigma P_x Q_y}$$

In an intertemporal comparison calculations are usually made for only one of these formulae, generally the Laspeyres. In an interspatial comparison neither country can be regarded as having any precedence over the other, and calculation in only one set of weights results in a marked bias against the country whose weights are used.[1] This is because differences in price structure and the pattern of production and consumption are much greater than in a short-run intertemporal comparison and reflect the normal inverse correlation between price and quantity.

Another important difference between comparisons over time and over space lies in the assumptions made regarding items not directly covered by the indicators used. In an intertemporal production index it is frequently assumed that the volume of production of minor products of an industry moves with that of the major commodities, which are therefore allocated the total weight attributable to the industry. A superficial examination of the data reveals that this assumption is quite untenable interspatially, as the proportions in which different commodities are

[1] See S. Adler and D. C. Paige, *International Comparisons of Consumption*, Paper presented to the 14th European meeting of the Econometric Society, Cambridge, 1952, p. 8.

produced varies very widely, and a minor commodity in one country may even be the largest product of the other country's industry. It is more realistic to assume that prices of the unmeasured commodities move with those of the measured products of the same industry. The application of this assumption entails the calculation of quantity indices for the minor products by applying the price indices of the major commodities to value series, and the procedure is facilitated by the fact that both sets of weights are used throughout the comparison. For consistency an X-weighted price index must be used to calculate a Y-weighted quantity index. Thus if $\Sigma P_x Q_x$ and $\Sigma P_y Q_y$ are the original values, the X-weighted price index (X=100) will be $\Sigma P_y Q_x / \Sigma P_x Q_x$, and the Y-weighted quantity index (Y=100) $\Sigma P_y Q_x / \Sigma P_y Q_y$. Then

$$\frac{\Sigma P_y Q_x}{\Sigma P_y Q_y} = \frac{\Sigma P_y Q_x}{\Sigma P_x Q_x} \times \frac{\Sigma P_x Q_x}{\Sigma P_y Q_y}$$

The measurement of net output

The above remarks apply equally to the final expenditure and the industry of origin approach, but in the latter case the basis of comparison is net output by industry, i.e., the difference in each industry between the gross value of production and the input of purchased goods and services. The indicators used in the typical Laspeyres production index are nearly always measures of gross output, and are only permissible on the assumption that the ratio of input to gross output is constant. If this assumption is not realistic, as in the case of an increased output of goods resulting, say, from greater mechanization and a higher consumption of purchased electricity, the gross output indicators will exaggerate the real increase in production by measuring both the increased output of the electricity industry and the whole of the resulting increase in the industry consuming the additional electricity.

Interspatial variations in the input-output ratio are much sharper than those found in a short period intertemporal comparison, and failure to take account of them may result in a consistent bias in favour, say, of the country using more indirect production methods. Two extreme examples may be quoted where gross output by itself is practically meaningless as the measure of the output of a particular industry. Firstly, different technological methods may produce identical gross outputs

from totally different inputs, as in the case of hydro-electric power and electricity generated from coal, or the production of sulphuric acid from crude sulphur and from pyrites, and, in this case, it clearly cannot be assumed that the input-output ratio is constant. Secondly, the number of processes performed within an industry may vary as a result of differences in the extent of vertical integration; the United States cotton weaving industry, for example, purchases raw cotton and performs both the spinning and weaving operations, while in the United Kingdom the corresponding industry purchases yarn from a separate spinning industry.

The 'double indicator' method

A true measure of net output can be obtained by using indicators of both input and output by the method described by Geary.[1] In the terminology used above, if P and Q are used to express gross output and p and q the input of materials and services, the net output indices in both sets of weights are given by the formulae:

$$\frac{\Sigma(P_yQ_x - p_yq_x)}{\Sigma(P_yQ_y - p_yq_y)} \text{ and } \frac{\Sigma(P_xQ_x - p_xq_x)}{\Sigma(P_xQ_y - p_xq_y)}$$

This approach has a considerable logical advantage, since, with the stage by stage deduction of intermediate products, the aggregates of both the industry of origin and the final expenditure sides of the national accounts will, in principle, balance in the other country's prices as well as in their own, so that the same result is arrived at by both approaches.

Paradoxical results may be obtained for particular industries if the raw material used in one country is in fact an uneconomic one in the other country's prices, so that in the extreme case $p_yq_x > P_yQ_x$ and a negative net output results. This would probably occur, for example, if United Kingdom electricity inputs and outputs were expressed in Norwegian coal and electricity prices.

In this instance the net result for the electricity industry considered in isolation is meaningless, but the global result is correctly measured, because the negative net output for electricity offsets the high value given in Norwegian prices to that part of United Kingdom coal output used as an intermediate

[1] See R. C. Geary, 'The concept of net volume of output with special reference to Irish data', *Journal of the Royal Statistical Society*, Pts. III–IV, 1944.

good in the production of electricity which in Norway is produced from a free good, water.

The use of double and single indicators

In an interspatial comparison the double indicator method is the only one that gives a completely satisfactory measure of true net output. In practice, owing to the limitations of the available statistical data, an apparent variation in the input-output ratio may be due less to a real difference in input per unit of output than to the crudity of the available indicators. If, as is frequently the case when quantity indicators are used, the output indicators ignore quality factors that are measured by the input indicators or *vice versa*, the double indicator method will only distort the result. Moreover, the single indicator available, while actually a crude measure of gross output, often gives a better approximation to net output.

This point can be clarified by an example. Suppose that data are available for the output of various types of knitting yarn, wool, cotton, nylon, etc., but the production of the knitting industry is available only in terms of the garments made, socks, stockings, pullovers, etc. An application of the double indicator method differentiating between the different types of input distorts the result because the inputs reflect the higher value of nylon but the outputs do not, and the country making more nylon stockings appears to be less efficient because it uses more expensive material to produce a standard quality of output. Even if the input is treated as a homogeneous commodity, 'knitting yarn', the input unit does not correspond to the output unit, and the weight of yarn consumed will vary with unmeasured differences in the type of garment produced, e.g., as between men's and children's pullovers, so that one country might appear to have a disproportionately high input merely because it produced more men's pullovers.[1] In this example it is clear that the available indicators, types of garments, provide a better estimate of the net output than of the gross output of the knitting industry, and the single indicator method is to be preferred in spite of the fact that it ignores variations in sub-

[1] In the case of women's stockings the argument is complicated by the fact that the knitting cost depends largely upon gauge, which is approximately inversely related to the weight of yarn used. This is not properly a justification of the use of input indicators, but it raises interesting possibilities for adjusting the single indicators for quality by the reciprocal of average weight.

sidiary inputs of fuels, chemicals, or purchased services, and in spite of the difficulty, which will be discussed later, of weighting the different indicators within the industry.

It appears that in quantity comparisons most industries with heterogeneous outputs present difficulties of this type when the double indicator method is used, but there are two classes of industry where its use is necessary and practical. The first of these comprises industries with products such as electricity, certain basic chemicals, and some unprocessed metals, where a standardized commodity may be produced by different methods involving different inputs. Even here the standard products are often produced jointly with extremely heterogeneous minor items and by-products, which complicate the problem. The second class, represented by agriculture and some other extractive industries, consists of those industries where the relationship between input and output is more indirect and frequently associated with differences in natural resources, so that it can generally be reasonably assumed that the indicators reflect genuine differences in the input-output ratio.

The double indicator method is more easily applied in comparisons based on the conversion of value series by price indices. The use of price indices is restricted mainly by practical considerations; apart from very standardized goods which are easily compared by either method, a satisfactory price index can seldom be constructed without some detailed field work to ensure uniformity in the items priced. Consequently the resources available for investigation inevitably limit this method to a few industry groups, such as clothing and engineering, whose products are particularly difficult to quantify.[1] When output prices are collected by some such method, it would be relatively easy to construct corresponding indices for inputs and it is highly desirable to do so. A price index does not involve the same quality simplifications as a quantity indicator, and thus, on the one hand the danger of systematically measuring input qualities that the output indicators ignore is eliminated, and on the other hand, there is no parallel procedure to the selection of quantity indicators that measure net rather than gross output. There is a further technical reason for using

[1] A detailed report on the construction of such indices is given in *An International Comparison of National Products and the Purchasing Power of Currencies*, Milton Gilbert and Irving B. Kravis, O.E.E.C.

double indicators with price indices; the value series on which these comparisons are based are nearly always derived from sales data (as no actual market value can be measured until a sale is made), and it is extremely difficult to ensure that such data do not contain a varying proportion of omissions, owing to further processing of intermediate products without a sale occurring, or duplications resulting from intra-industry sales. If both input and output indicators are used errors resulting from this factor will be very small, since duplications and omissions will cancel out in the original values (provided that the true sales and purchases of the industry are used), and in the converted values they will only be reflected as a slight error in the weighting of the price indices.

The problem of duplication can be quite formidable even with quantity indicators, but then it is frequently possible to make use of series based on total production and not on sales, or, failing this, to screen the items carefully, omitting intermediate products of the industry which are likely to involve duplications and omissions. The difficulty still remains in the case of minor products which are measured by converted value series. If the proportion of such products is appreciable and duplication cannot be eliminated by screening the items, it is better either to make the generally less satisfactory assumption that the quantity of parts and accessories moves with that of the main product or to abandon the quantity approach altogether, in spite of the fact that good indicators are available for a large part of the field.

The 'ring fence' method

Practical measurement problems can also be reduced by drawing a ring fence round certain industries and ignoring transactions which take place within the ring. By the double indicator method both the inputs and outputs of the group as a whole must be measured and the result is then conceptually unaltered because the transactions within the ring cancel out. This is only true, however, if the intermediate products within the ring can correctly be expressed in identical units both as inputs and as outputs. Suppose, for example, that a ring is drawn round the weaving and clothing industries but that the output indicators for weaving differentiate between two qualities of cloth and the clothing indicators do not measure cloth

quality. In this case the most accurate result is obtained if qualities of cloth are differentiated in the output of the weaving industry but cloth is treated as a homogeneous input into the clothing industry. Inputs and outputs are still equal in the original values but not in the converted values, and the use of the 'ring fence' method omits the factor 'quality of cloth' from the comparison.

In certain cases the ring fence method can be used with single indicators, on the assumption of a constant input-output ratio for the group as a whole. The simplest example of this is when the total output of a particular industry forms the input of another industry, and so the output of the end product only is measured but is weighted by the net output of both industries.

Substitute indicators

So far the discussion has been concerned with different ways of applying basic quantity indicators and indicators obtained by converting values with price indices. These are the only true measures of production, but on occasion recourse must be had to cruder indicators which give only an approximate measure of net or gross output because they depend on less general assumptions. These indicators are of four main types:

(1) Value series converted by price indices imputed from original or derived indices calculated for other industries.
(2) Input of material.
(3) Employment, preferably adjusted for productivity.[1]
(4) Indicators derived from related series not directly measuring input or output.

The first of these is only an extension of the method of treating minor commodities in a quantity comparison or of items not in the sample in a price conversion. Its validity depends on the similarity of conditions in the industries concerned; it might, for example, be reasonably assumed that price ratios for making up light clothing would apply also to bed linen and household textiles.

The use of inputs of material as indicators to measure output is necessarily crude because it not only assumes a constant

[1] For a description of (2) and (3) in intertemporal comparisons see C. F. Carter, W. B. Reddaway, and R. Stone, *The Measurement of Production Movements*, Cambridge, 1948, pp. 34–40.

value of processing per unit of material, but in most cases disregards variations in the consumption of minor or substitute commodities (e.g. the use of rayon or woollen yarns in an industry primarily manufacturing cotton cloth). For this reason the use of the method should be restricted as far as possible, but it is often the only practicable way of comparing certain industries, such as that making miscellaneous metal products, with a fairly homogeneous input but a highly heterogeneous output.

Employment is unsatisfactory between countries because of the wide variations in labour productivity. Adjustment for this factor is made extremely difficult by the fact that over and above the difference in average productivity between two countries there may be a very wide range in the relative productivity of the various industries.[1] In certain instances, however, the productivity ratio of an industry or industry group may legitimately be used to adjust employment in neighbouring industries, e.g., the output of lace or narrow fabrics might be measured by employment adjusted by the productivity ratio of other textile industries. It is also possible to adjust employment on the basis of a technical study of productivity, but such studies are usually based on a small sample of plants, selected to illustrate differences in method or as representative of 'best practice', and it is very difficult to relate them to global averages of actual production.[2]

The last group of substitute indicators consists of series which are believed to be causally related to the item to be measured although not actually part of the input or output process. In some circumstances it might, for example, be desirable to use an index of temperature to measure variations in fuel consumption for space heating; the number of deaths might be taken as the indicator of tombstone production, or the number of vehicles on the roads as a measure of road depreciation. Such indicators are extremely crude, however, and while they may be permissible for small items in an intertemporal comparison, there are very few cases where the same causal relationship could be assumed as between two separate countries, e.g., fuel consumption will increase in both the United States and the United Kingdom when the temperature falls, but it would be

[1] See L. Rostas, *op. cit.*
[2] *Idem*, pp. 7–9.

exceedingly rash to assume that consumption in New York is higher than that in London in direct proportion to its colder winter.

Partial use of double indicators

In any particular investigation a variety of methods and types of indicator will be required. While the double indicator method remains conceptually the only satisfactory one, in practice it will probably only be possible to apply it in a minority of industries. In other industries it may be possible to improve the single indicator estimates by a partial use of input indicators, usually to measure variations in certain non-specific inputs (e.g. fuel, transport, and some services), in industries for which the indicators are too crude to permit input indicators to be applied to the specific raw materials[1] (e.g., raw cotton in yarn, timber in furniture, or leather in shoes). If $p_j q_j$ and $p_k q_k$ are the two types of input, the Y-weighted formula for this procedure would be:

$$\frac{\Sigma\left[(P_y Q_y - p_{jy} q_{jy})\frac{Q_x}{Q_y} - p_{ky} q_{ky}\frac{q_{kx}}{q_{ky}}\right]}{\Sigma[(P_y Q_y - p_{jy} q_{jy}) - p_{ky} q_{ky}]}$$

It follows that when convenient the measured inputs $p_k q_k$ can be deducted globally for a whole sector or even for the whole economy. In order to apply this method the only data required for the individual industries are the values of the inputs in sufficient detail to separate $p_{jy} q_{jy}$ and $p_{ky} q_{ky}$. Whether deductions are made globally or by industry will largely depend upon the importance of the items deducted to the comparison of the individual industries; one advantage of the global deduction is that it enables account to be taken of the inputs of items, such as fuel, which may be of little importance in many individual industries but are significant in the aggregate because of a general trend to greater utilization in one country. The extent to which such deductions are made will be mainly determined by the data available, but clearly care must be taken that materials are not deducted for which substitutes are assumed,

[1] The term, specific is used here in a restricted sense to cover those raw materials which, after processing, constitute the physical content of the end product, since these are the inputs whose quality variations are likely to be retained in the final product.

for lack of full information, to move with the output indicator, e.g., it would be misleading to deduct coal and not electricity or the input of rayon yarn into cloth and not that of cotton yarn. Partial input indicators need not be restricted to industries for which true quantity indicators or price indices are available. Even when the input of the major raw material is used as the output indicator, it may still be desirable to make allowance for varying inputs of, say, fuels or transport.

III. MANUFACTURING AND MINING INDUSTRIES

This sector has been defined to include construction and public utilities in addition to the manufacturing industries proper and mining. The basic methods have already been reviewed, and it only remains to consider detailed problems specific to this sector. The greater divergence in the industrial structure of different countries calls for a larger number of indicators than are required in a comparison over time, but for selected years these are generally available and the comparison is not restricted, as in the intertemporal case, to series that are available at frequent intervals. The data required can be obtained to a large extent from the censuses of production but will require adjustment if the coverage of the two censuses varies, or if they do not coincide with the year of the comparison. Provided the required adjustment is fairly small it can be made to the aggregate on the basis of internal indices for each country.

When census of production data are used distinction must be made between the industrial classification of goods and the classification of firms to industries. Information on inputs, employment, net output, and global gross output relate to the firms within an industry and include products made by these firms that are classified to other industries, but tables of commodities produced are usually available for total production (or sales) of the products assigned to the industry wherever they are made. If complete inputs and outputs were measured throughout, these discrepancies would cancel out, but even then much of the interest of the individual industry comparisons would be lost, since we are interested in the relative quantities of yarn spun rather than the relative products of somewhat arbitrarily defined 'spinning industries'. In practice single

indicators have to be used over much of the field, and the divergence may lead to a distortion of the net output weights. The simplest solution, therefore, is to adjust the global data to a commodity classification *pro rata* to the gross output values. This appears perfectly permissible if the net adjustment is small, but if there is a considerable overlap between industries it may be necessary to combine them on the 'ring fence' basis.

Partial vertical integration presents some difficulty in making an adjustment of this kind. A few firms in the United States knitting industry spin their own yarn, and adjustment for this activity can easily be overlooked because the yarn spun in the knitting industry is not sold and does not enter into the gross sales value of the industry. As long as the quantity is known, a value can be imputed to it and adjustment made on this basis.

If extensive vertical integration exists, as in the United States cotton spinning and weaving industries, the only solution is to draw a 'ring fence' round the industries, because in a large scale *pro rata* adjustment, the assumptions of a constant input-output ratio and similar average values of intermediate products made in integrated and in independent plants may completely distort the result. This would clearly be so in the United States cotton industry where the cost structure of the independent spinning mills differs from that of the integrated plants both because they depend on the market for yarns and because of variations in average age and regional distribution.

When complete input indicators cannot be used, the 'ring fence' treatment of overlapping industries accentuates the problem of weighting the various indicators within the group. This problem arises, of course, whenever the single indicator method is used with more than one output indicator per industry, but the larger the industry or industry group and the more diverse the products, the greater is the effect of the weights on the aggregate result. Frequently the only possible approach is to assume constant input-output ratios between the products of the industry and to weight by gross values, but whenever possible *ad hoc* methods of improving this weighting should be devised. Sometimes this can be done from technical data or by making a different assumption that appears more realistic for the particular commodity, e.g., by combining the indicators on the assumption that net value is constant and only the input varies, or, conversely, by deducting the average input from each

unit of gross value, on the assumption of constant inputs and a variable degree of processing.

An illustration of one of these *ad hoc* methods can be drawn from a comparison made of the United States and United Kingdom woollen and worsted industries, where it was highly desirable to measure both the intermediate and the end products but vertical integration made it impossible to treat the different stages as separate industries. United Kingdom total make of tops was nearly 90 per cent of that of the United States, of yarns over 70 per cent, and of fabrics less than 50 per cent. Part of this divergence could be accounted for by United Kingdom net exports of tops and yarns, but it was also due to a larger proportion of woollen knitted goods and to the production of heavier cloths. Neither of these factors could be satisfactorily measured from the data available for the end products, and so to omit the intermediate products would have biased the result against the United Kingdom. On the other hand, in view of the importance of the weighting in this particular case, it seemed unsatisfactory to weight the whole series by gross values, and the integration made it impossible to trace actual inputs into the various processes. The method chosen, therefore, was to group the products according to the main category of raw material, e.g., raw wool, woollen yarn and worsted yarn. Commodities within each group were weighted by gross values, but the groups were aggregated with weights obtained by deducting from the gross value the value of an equivalent tonnage of raw material. The relative weight used included, therefore, wastage allowance, fuel and subsidiary raw materials, in addition to the true net value, but the proportion of extraneous factors in the weighting system was greatly reduced.

Finally, consideration must be given to the treatment of 'unique commodities' and 'unique industries', i.e., the products and industries found in only one of the pair of countries being compared. Here distinction must be drawn between the genuine unique commodity that is neither produced nor consumed in one of the countries (e.g., natural gas as between the United Kingdom and the United States), commodities which are produced in one country but only imported by the other, and commodities which are non-comparable, actually or because of classification problems. There is no conceptually satisfactory method of handling the first of these classes on any approach,

but, fortunately, it accounts for only a small part of the production of most modern economies. One solution is to convert value series by the price index of somewhat similar industries, or, if there is no parallel industry, by the index of manufacturing industry as a whole. Since the price indices apply to gross outputs and inputs but it is the net output that is to be measured, where possible separate indices should be applied to the input and output values, but in a crude approximation it may be preferable to assume that the same price ratio applies to both, i.e., to use one index to convert the net output value. Alternatively, employment may be used as the indicator, making some adjustment for productivity based on the results obtained in other industries.

Commodities that are produced in one country and only imported by the other are considered more fully in the following section on agriculture, since they are more significant in that field. Here it need only be said that in principle they should be converted at the import prices, but care must be taken not to apply an artificially high conversion rate by using this procedure for an item which is not consumed in bulk in the non-producing country but is imported in small quantities to meet a small luxury demand. Such items should be treated as unique or non-comparable commodities.

The term non-comparable commodities has been used to describe similar items which cannot be directly compared either because of differences in style and composition attributable to variations in demand (e.g., a consumer preference for shorter socks or thicker overcoats in cold climates), or because the census classifications make it impossible to sort heterogeneous items into comparable classes. Commodities of the first type can sometimes be compared after a technical adjustment of the unit, e.g., sock production in terms of socks of a given length, but if this is not possible the best solution appears to be to handle them in the same way as the minor products of an industry and to convert value series with the price index of other associated products. Non-comparable heterogeneous groups of items can be converted in the same way, or, if they are of sufficient magnitude, by a specially constructed price index based on the identifiable items in both groups.

IV. AGRICULTURE

Differences in climate and natural resources have a direct bearing on the agricultural system which greatly increases the difficulty inherent in an interspatial comparison of agricultural output. In the first place the production of many agricultural products is extremely localized, so that between almost any pair of countries there will be commodities produced in only one of the pair, and the proportion of these is often considerable. As between the United States and the United Kingdom, for example, nearly a quarter of the end product of agriculture in the former consists of commodities that are not produced in the latter. Secondly the ratio of input to output varies as a result of differences both in the position and nature of the farm land and in farming practice. Thus account must be taken not only of variations in the input of fertilizers and purchased feeding-stuffs but of the purchased fuels and materials required where tractors are used, as compared with the use of horses fed off the land.

The variation in inputs can be handled by the double indicator method described in section II. Agricultural products are relatively standardized and the qualitative relation between inputs and outputs comparatively indirect, so that in this sector there is little risk of input indicators distorting the result on account of the crudity of the output indicators. The practical application of the method will be facilitated by treating agriculture as one 'ring fence industry' and measuring only the inputs entering and the outputs leaving the sector. Production of feed, seed, livestock, etc., used for further agricultural production is thus omitted, regardless of whether or not it is transferred from one part of agriculture to another. Farm households should, of course, be regarded as outside this ring, so that food produced and consumed on farms is included in the end product of agriculture. On this basis the inputs and outputs of the agricultural sector are relatively homogeneous and a fairly complete coverage of both inputs and outputs by quantity series appears quite feasible.

The problem of measuring commodities produced in only one of the two countries is made easier by the fact that among developed countries the consumption of particular agricultural products is very much more evenly distributed than their production, and the number of genuine unique commodities

that are neither produced in nor imported by one of the countries is very small. In Western countries the only major item appears to be rye, whose consumption is largely limited to the countries which grow it. The problem here appears to be that the various bread grains are very close substitutes for one another, and it may be preferable to define the commodity as 'bread grains', adjusting the unit, if necessary, on account of technical differences such as the average extraction rate. The other items in this class are extremely small, e.g., sweet potatoes, minor categories of fruits and vegetables, local cheeses, etc., and can be covered by using the price index of similar commodities to convert value series.

Commodities produced in one country and only imported by the other can be handled by using the import price at port as the equivalent of the farm price. This price will, of course, include the freight charge to the frontier, but it must still be assumed to be at least as low as the potential farm price within the importing country, or production would presumably be undertaken.

The comparison being at factor cost, an anomaly arises in the case of commodities which are partly produced at home and partly imported, since after allowance is made for tariffs and subsidies, there may be a considerable spread between the import price and the farm price. An extremely small home production may be treated as a separate commodity, analogous to English hothouse peaches compared with American peach production, but if the output is sufficient to be regarded as 'bulk production', it would appear that the farm price must be used, however inappropriate it may appear to the relatively large output of the self-sufficient country. To alter the price for both countries will completely upset the input-output relationship of the base country, while to use the import or average price for the large scale producer changes the quantity ratio in favour of the base country and, incidentally, gives the somewhat absurd result that the greater the spread between the prices, i.e., the less efficient the base country's production, the greater its relative output.

V. TRANSPORT AND COMMUNICATIONS

In considering the transport and communication industries distinction must be made between that part of the output sold to

final consumers and business purchases of transport and communications. Whereas the first clearly forms part of the final product, transport and communications services to industry constitute intermediate products, and for these it has to be determined whether they make a separate net contribution to the real product that is not measured by the indicators for the other sectors. In an intertemporal comparison it is arguable that an increase in the transport per unit of output does represent an increase in the real product because a commodity that has been transported some distance from its place of production is a different and more valuable good than a physically identical commodity ex factory. Thus an increase in transport probably represents a more widespread distribution of goods, which is not measured in the production indicators. There is an apparent exception in the case of an increase of transport resulting from a change in the location of production or more movement of intermediate products, but logically these could be covered by identifying physically similar commodities produced at separate geographic points as separate commodities.[1]

In a comparison between countries a different approach is required because, unless we are prepared to accept physically identical goods at different points in space as identical commodities, no comparison can be made at all. A motor vehicle in Los Angeles is a different and more expensive commodity than the same model ex factory Detroit and this is reflected in a higher price. But is the Los Angeles car, *ceteris paribus*, more valuable than one that has been manufactured in Oxford and transported the shorter distance to Edinburgh? If we are to have any basis for comparison at all, we must decide that it is not a more valuable car, but merely one that has required a greater input of transport to get it to the final consumer.

Differences between countries in the volume of transport per unit of output may be explained by variations in any of the following factors:

(1) Density of population and distribution of natural resources.

(2) Extent of geographic concentration of production affecting the average distance to markets.

[1] See W. B. Reddaway, 'Some Problems in the Measurement of the Real Geographic Product', *Income and Wealth, Series I* (1951), p. 273.

(3) Degree of vertical integration, affecting the volume of transport of intermediate products.
(4) The size of the market, affecting the range of goods available and the distribution of goods over time or between town and country.

Only the last of these factors can be said to make a net contribution to the final product, and in practice this cannot be isolated from the other three which may well be the more significant. It would be misleading, therefore, to consider transport as an indicator of the range of choice offered to consumers, and in practice we must regard this as immeasurable and treat transport as an input,[1] on the assumption that variations in the amount of transport per unit of output are pure cost variations similar to the cost variations involved in extracting metal from different qualities of ore or weaving cloth on different types of loom.

The actual method of implementing these assumptions can be more simply described if in the first place we confine our attention to freight transport by rail. Since this freight transport is to be treated as an input, the gross outputs of the industries must include the transport cost, which can most easily be done if outputs are priced on a delivered basis. Conceptually transport cost could also be allocated to industries on the basis of the cost of transporting inputs, the commodity inputs being broken down into F.O.B. price and transport charge, and this method would be nearer to the original data in the case of census material. It would, however, impute a large part of the transport costs to the distributive industries which would be a rather illogical weighting system since the volume of transport is clearly determined by the locations of the producer and the user rather than that of the distributor. In practice, also, the latter method would be extremely difficult to carry out, because transport statistics are usually available by type of commodity, which can be attributed to producers but not to purchasers, e.g., all coal moved on the railways can readily be attributed to the coal-mining industry, but it would be exceedingly difficult to allocate it among the various industries which consume coal.

[1] For an interesting discussion of the 'transport coefficients', i.e., the transport requirements per unit of output, in the U.S.S.R. and for a broad comparison of these coefficients with those of the United States, see James H. Blackman's chapter on Transportation in *Soviet Economic Development*, editor Abram Bergson, Row Peterson, 1953, pp. 126–57.

The net output of the producing industries can then be expressed by the formula given for the partial use of indicators, which in own prices is

$$\Sigma[(P_yQ_y-p_{jy}q_{jy})-p_{ky}q_{ky}]$$

where P_yQ_y is the gross output on a delivered basis, $p_{ky}q_{ky}$ is the transport input and $p_{jy}q_{jy}$ the sum of all the other inputs. The output of the transport industry can also be expressed as

$$\Sigma[P_{fy}Q_{fy}+P_{gy}Q_{gy}-p_{hy}q_{hy}]$$

where $P_{fy}Q_{fy}$ and $P_{gy}Q_{gy}$ are the gross revenues from freight and private passenger transport respectively, and $p_{hy}q_{hy}$ the total input into transport. Since freight output is entirely an input into industry,

$$P_{fy}Q_{fy}=\Sigma p_{ky}q_{ky}$$

and can be cancelled out on a 'ring fence' basis, and the aggregate net output index expressed as

$$\frac{\Sigma\left[(P_yQ_y-p_{jy}q_{jy})\frac{Q_x}{Q_y}\right]+\left(P_{gy}Q_{gy}\frac{Q_{gx}}{Q_{gy}}-p_{hy}q_{hy}\frac{q_{hx}}{q_{hy}}\right)}{\Sigma(P_yQ_y-p_{jy}q_{jy})+(P_{gy}Q_{gy}-p_{hy}q_{hy})}.$$

The industry weight, $P_yQ_y-p_{jy}q_{jy}$, is expressed in the formula as gross output C.I.F., minus inputs other than transport. This is equal to the net output of industry plus the gross transport revenue imputed to it, and the latter method of arriving at the weight is operationally easier to obtain, at any rate where single indicators are used for this expression, since it avoids any error to a mixture of C.I.F. and F.O.B. prices in the original data. It should be noted that the part of net transport output included in the final total, $P_{gy}Q_{gy}-p_{hy}q_{hy}$, represents the gross revenues of private passenger transport (business passenger transport is at this stage ignored), less the total of inputs into all transport, and has therefore, no significance in isolation. To obtain a meaningful comparison for the transport industry as such it would be necessary to include the gross output of freight transport, although this is excluded from the aggregate index.

The comparison of road transport is the same in principle, but is complicated in fact because the vehicles used for freight may be owned by the producing industry or by a separate road transport industry. It cannot be assumed that the proportion of

integrated transport is the same in both countries, and therefore in a specific comparison of the road transport industry it would be necessary to use quantity indicators relating to the services of all vehicles regardless of ownership and to adjust the weights accordingly. In the formula used above, however, the output quantity indicator cancels out, and so only an adjustment of input indicators and weights is required, i.e., the inputs purchased by the producing industry for the operation of transport must be transferred from its own inputs, $p_{jy}q_{jy}$, to those of the transport industry, $P_{hy}Q_{hy}$.

The same method can logically be applied to business passenger transport and communications inputs, but these will have to be distributed over the whole economy and not merely over the production industries. With these services it may also be reasonable to assume that their business utilization is proportionate to net output, in which case the relative weighting of the various user-industries is not affected.

VI. DISTRIBUTION

In measuring the output of the distributive services distinction must be made between the volume of goods distributed and the quality of the service. This quality factor, which is reflected in the amount of personal attention, retail deliveries, the location of shops, etc., varies considerably from country to country and probably accounts for a large part of the variation in the cost of distribution, but appears to be particularly insusceptible to measurement. On an intertemporal basis part of the quality factor might be measured by treating goods distributed through different types of retail outlet as separate commodities, but institutional differences make it impossible to draw up parallel classes of retail output in different countries. Labour input is an equally unsatisfactory indicator owing to divergences in productivity.

It appears, therefore, that in interspatial comparisons measurement must be restricted to the volume of goods distributed, ignoring the quality differences in the service rendered to the consumer. This volume of goods may be measured in physical quantities, in sales deflated by an appropriate retail price ratio, or by the volume of production calculated for manufacturing industry adjusted for imports, exports and sales

to industry. In practice a combination of all three methods will probably be required, but in any event the various commodities and commodity groups will have to be aggregated with weights based on their distributive margins. In view of differences in the pattern of distribution between countries it seems preferable to treat wholesale and retail distribution as one industry, when the distributive margin will be the full spread between factory prices and retail prices.

In trades such as the sale of perishable foodstuffs, where there is a considerable physical wastage, it would be desirable, if possible, to use indicators of both input and output, since the ratio may vary between countries. For most distributive trades, however, it will be necessary to assume that the quantity of goods sold is equal to that purchased net of stock changes, so that there is no advantage in the double indicator method.[1] Partial input indicators can still be used, however, as described in section II above to make allowance for variations in subsidiary inputs, such as purchases of fuel and communications.

VII. SERVICES

As in the case of the transport and communications industries distinction must be made between services to business, which constitute intermediate products, and services to final consumers. The more important services to business include a large part of the activity of various professions – (lawyers, architects, accountants, etc.) – of financial intermediaries, such as stockbrokers, of insurance organizations, and the major part of banking. In principle the work of these industries should be divided between the business and the private sectors, but in the case of banking and some other items it is so difficult to make this split and the service rendered is so difficult to measure that the only practical solution appears to be to regard them as entirely services to business.

The method of handling service inputs into industry has been discussed in the section dealing with transport and communications. The miscellaneous services included in the present sector cannot be quantified and very little information exists on their inputs. In practice, therefore, a single indicator 'ring fence' method has to be used, and the net output weight of these

[1] Algebraically it is assumed that $P_xQ_x - p_xq_x = (P_x - p_x)\,Q_x$.

services is added to that of the various productive and distributive industries, the output of the whole group being measured by the production and distribution indicators. Conceptually the service weight should be distributed according to the purchases of the various industries, but in many cases this can only be crudely estimated. The 'ring fence' approach has an additional advantage in this sector, because it avoids any duplication or omission that might arise from institutional differences between countries in the utilization of service industries, e.g., the services to industry of a lawyer or an accountant are given the same treatment whether he is directly employed by the industrial firm or engaged in a separate enterprize.

There is little or no difference in the treatment of services to final consumers between the industry of origin and final expenditure approaches. The indicators available are generally too crude for the application of input and output indicators and in some cases those used in a comparison of final expenditures are actually more appropriate measures of net than of gross output, e.g., employment, number of admissions to cinemas, etc. A full discussion of the indicators and methods which may be used for these industries in the final expenditure approach is given in the O.E.E.C. reports on international comparisons of national products.[1] Briefly, the items included and the methods used are as follows:

(*a*) *Housing services*

The services of the existing stock of houses can most easily be compared by a quantity comparison based on the number of houses, adjusted for such quality factors as can be measured, e.g., size and floor space, age composition, plumbing facilities, etc.

(*b*) *Private domestic service*

Employment gives the true indicator in this case, since the labour and not the labour product is the commodity purchased by final consumers.

(*c*) *Other household and personal services*

These consist chiefly of laundries, dry cleaning, shoe repairs, barbers and beauty parlours. The best basis of comparison appears to be the conversion of expenditures by price indices

[1] Milton and Kravis, *op. cit.*, Chapter IX.

based on a sample of charges. If adequate data can be obtained it is highly desirable to use the double indicator method and convert inputs also.

(*d*) *Recreation and entertainment*

The largest item in this group for many countries is cinema expenditures, which can be fairly readily compared by the number of admissions. The other items include such things as catering (service element only), theatres and concerts, professional sport, clubs, betting, etc., which owing to their diversity have mainly to be compared on the basis of employment.

(*e*) *Health Services*

The value added in the health services industry can only be measured by the services of the professional and other personnel, indices derived from the numbers of doctors, nurses, dentists, etc., being combined with weights based on relative earnings. The same method is employed in the final expenditure approach but these indicators must also be used to measure the goods and services used in the industry, which are not included in the measure of net output. Since there is no means of quantifying the service actually rendered, the true value added to the goods and services purchased cannot be measured in either approach, e.g., we can measure the number of doctors and the supplies of penicillin, but we cannot measure the additional service rendered by a doctor when he has adequate supplies of penicillin.

(*f*) *Education*

This group presents very similar problems to the health services. The main personnel indicator is that of teachers, who may be classified according to their employment in primary, secondary or higher education. In view of different institutional patterns the only way of defining the different levels of education appears to be on the basis of the ages of the pupils.

(*g*) *Miscellaneous services*

These include religious and welfare activities, private legal services, private insurance and a number of minor items. For most of them no output indicators are available and it would be impossible to separate the employment in the industries between services to final consumers and those to business. They can only be handled, therefore, by converting value series with the price index applicable to other service industries.

VIII. GOVERNMENT

In order to secure comparability between countries the definition of government activity must of necessity be a narrow one. Thus public health and education services are combined with their private counterparts, and all publicly owned enterprises such as post office, wireless transmission, public transport and other nationalized industries are transferred to the appropriate sector. In principle, government services to industry should be treated as an input into industry by the method described for the private enterprise services to business. Otherwise double counting would occur, if, for example, both the activities of a government export agency and the goods sold as a result of these activities were measured in full.

After these deductions have been made the remainder of government activity will consist mainly of administration and those items, such as defence and the police service, which have been described by Reddaway as 'regrettable necessities'.[1] In practice, employment is the only indicator by which this restricted government activity can be measured. Conceptually, however, the employment indicator may be regarded as a crude measure of the value of government service, or government may be regarded as a final consumer purchasing labour service. In either case it appears impossible to make any objective allowance for differences in productivity whether due to personal efficiency or to variations in purchased goods and services.

[1] W. B. Reddaway, 'Movements in the Real Product of the United Kingdom 1946–9', *Journal of the Royal Statistical Society*, Series A, Vol. CXIII, Part IV, 1950.