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ALTERNATIVE METHODS OF MEASURING CAPITAL

By T. Barna

I. THE TWO CONCEPTS OF CAPITAL

THE term 'capital' is generally given one of two alternative meanings. First, it can mean the individual's command over resources in the financial sense. This concept comprises the value of all assets belonging to an individual, including non-reproducible assets like land and natural resources and intangible assets like patent rights and trade-marks. The assets included are valuable simply because they can be sold to other individuals. The definition of *financial capital* thus depends on social institutions which determine the extent to which rights in property can be transferred between individuals. This concept of capital, which is primarily applicable to the individual, is extended to economic units such as business organizations and to the nation itself.

Secondly, the term 'capital' can mean a factor of production, one of the three major factors – Land, Labour, and Capital – distinguished in economic theory. In this sense, capital consists of physical objects which have been produced by the economic system and which are, in their turn, used for the production of other commodities. *Real capital* excludes land and natural resources; and it is difficult to work with a concept which includes intangible assets. Real capital is essentially a social concept, but it can be extended to economic units such as industries or firms.

The distinction made here between financial capital and real capital is important, and it should help to clarify the discussion of definitions and methods of measurement. There are a number of different purposes for measuring capital and a number of approaches to the problem of measurement; it will be found that each alternative is associated with one or the other of the two main concepts.[1]

This last point will be more fully developed in the next section, while subsequent sections discuss the principles of some statistical techniques; Section 3 deals with survey methods aiming at

[1] It is, of course, possible to reconcile the statistical difference between the two concepts.

a direct measurement of the value of capital, Section 4 with aspects of the index-number problem which especially affect the measurement of capital, and Section 5 with the so-called 'perpetual inventory' method of estimation.[1]

II. THE PURPOSE OF MEASURING CAPITAL

Today the chief interest in estimates of capital is not so much to obtain a measure of 'national strength' or of 'welfare' but rather to analyse the social and economic structure. In practice this means that the aim is to obtain not just a comprehensive and unique total of national capital but to estimate a set of analytically significant components; whether a uniquely defined and measured total is possible or not, is no longer regarded as an important issue. The set of estimates of capital can be analysed *either* by examining the interrelation of different components *or* by relating it to measures of income or output flows and measures of other factors of production (that is, labour and natural resources).

The purposes for which estimates of capital are made can be divided into three broad categories connected with the problems of the distribution of wealth; social accounting; and economic development and growth.

The problem of the distribution of wealth and of taxable capacity

The purpose of estimates falling into this category is to establish the relative shares of individuals or groups of individuals in total wealth. This also gives a measure of taxable capacity and the basis for proposals for the taxation of wealth. Estimates of the value of public property are incidental to the main purpose but are an important complement in so far as they indicate the relative importance of public and private property.

For the purpose of indicating the distribution of wealth, capital is understood in the financial sense, and therefore it follows that valuation must be based on market prices. The relevant statistical sources are normally a by-product of the ad-

[1] Much of this paper is an exposition of familiar views, and I have not disturbed the text by references to standard works. For a more systematic account of the problem of national capital cf. S. Kuznets 'On the Measurement of National Wealth', *Studies in Income and Wealth*, Vol. 2, N.B.E.R., New York, 1938, and R. W. Goldsmith, 'Measuring National Wealth in a System of Social Accounting', *Studies in Income and Wealth*, Vol. 12, N.B.E.R., New York, 1950.

ministration of taxation, and the main problems discussed by the estimators are technical rather than theoretical ones. These technical problems arise under two headings: the interpretation of tax statistics and the adjustments to be made to them; and estimates for the area not covered by tax statistics.

Estimates of the distribution of wealth are well developed and easily understood in countries which have capital taxation of one form or another. From the point of view of the statistics to be derived from them, capital taxation can be of two types: annual taxes or specific levies on capital, or taxes on capital passing at death from one owner to another. The latter type of tax (death duties) gives rise to interesting problems of estimation in so far as the amount of capital assessed for taxation in a particular period (a year or the average of several years) can be regarded as a sample of all capital in personal ownership. Such estimates have been particularly popular in England during the past fifty years.[1] It should be emphasized, however, that most of the discussion around this method was concerned with the sampling problem rather than with the central problems of measuring capital.

The most effective form to analyse the distribution of wealth is by fitting Lorenz curves or log-normal curves, when the distribution can be described by one or two parameters (such as the Gini-coefficient).[2] Put into this form, the different distributions should be comparable through time and between countries.

The problem of social accounting and of economic research based on social accounts

Striking attempts were made in recent years to extend the system of national income accounts to embrace capital accounts. The reason for these attempts is a dissatisfaction with the existing system of national income accounts as a sufficient basis for the analysis of the behaviour of the economy. For the fuller understanding of the movements of the economy capital accounts, as well as income accounts, are necessary. In other

[1] Cf., for instance, H. Campion, *Public and Private Property in Great Britain*, Oxford, 1939.

[2] Although originally started in connection with distributions of income and wealth, the study of these parameters received a stimulus from the recent interest in the measurement of business concentration. Cf. P. E. Hart and S. J. Prais, 'The Analysis of Business Concentration: A Statistical Approach', *Journal Royal Statistical Society*, Series A, 1956.

words, a stock-flow type of dynamic analysis requires the support of a more extensive system of social accounts.

The need for capital accounts was, of course, always recognized in connection with the banking sector. Here behaviour is usually explained in terms of the items of the capital account – the various 'liquidity ratios'. In other sectors of the economy, though the influence of stock items on behaviour may not be as dominant as of flow items, capital accounts are essential for the measurement of rates of growth.

The logical problems of extending social accounting to include an articulate system of capital accounts are not difficult to solve. Instead of incomings and outgoings, the accounts will show assets and liabilities. Capital accounts can be drawn up for each sector for which we have income–expenditure accounts. The items in the capital accounts can be classified in various ways, including the degree of liquidity of the asset or liability, legal criteria, or physical characteristics.

A number of problems, analogous to those encountered in national income accounting, remain to be solved, and we need generally agreed conventions on their treatment. It is not within the scope of this paper to discuss these problems, but two illustrations are given.

First, in an articulate system of accounts the classification of items ought to be consistent between accounts, but there are difficulties. An individual shareholder, for instance, regards shares in a first-class company as an easily marketable asset, but from the point of view of the company the corresponding liability is of a long-term nature. In an analogous way, in national-income accounting the individual may regard payments of death duties as on capital account, but the Government may regard the corresponding receipt as on revenue account.

Secondly, we have to decide how far assets and liabilities shown on a given account should be 'gross'. For instance, if an industrial undertaking is using rented buildings or plant, should it show their value among its assets and liabilities? In ordinary commercial accounting this is not done, but when comparing one industry with another it might be an advantage to show rented assets on both sides of the balance sheet. There is nothing illogical in this procedure, since the firm is normally responsible for the asset rented by it. The analogous problem in national-income accounting is the routing of transactions in input–output

tables. Alternative solutions are possible, but, in some instances, a particular solution is generally accepted as the most convenient one.

For social-accounting purposes capital is conceived again in the financial rather than in the real sense. Since assets and liabilities derive from ownership, valuation can in principle be based on recorded transactions. There are, however, two alternative valuations possible, at cost or at market price. The values of some, but not all, items in the capital accounts will be different according to which method is chosen, and this difference can be quantitatively large with long-lived assets, especially in periods of changing prices and interest rates.

In practice, neither market prices nor costs are fully available. Market prices are typically available only for a relatively small proportion of capital items, and the value of the bulk is estimated from this proportion or is imputed. Costs, on the other hand, have often been lost in the records or superseded by the last recorded price when there was a change in ownership. Thus balance sheets are generally at cost, but when assets are acquired second-hand it is the cost of acquisition and not original cost which is recorded. Further, balance sheets are subject to revaluations.

It should be noted that capital accounts with items valued in terms of cost are generally consistent with income–expenditure accounts,[1] but capital accounts based on market prices are not. Revaluations disrupt the simple arithmetic connection between the accounts. However, this is not a reason for preferring one basis to the other. The chief criteria for choice should be impact on behaviour rather than simplicity of calculation.

It is probably true that on the whole market prices rather than original cost affect the behaviour of individuals, business, or the Government. For instance, the ease with which a company can raise new money from shareholders is a function of the market value rather than of the cost of its assets. If this is so, then the system of capital accounts ought to be in terms of market prices.

At the same time, it is recognized by those who study economic behaviour that the original cost of assets also influences behaviour. Tax laws, for instance, are generally based on cost,

[1] This is so if realized capital gains or losses are brought into the income statement.

and for this reason valuation at cost is relevant. Hence, occasionally, a concession must be made and items valued at cost, but this ought to be a supplement to the main principle of valuing at market price rather than a substitute for it.

Market price in this context need not be understood in the literal sense as the price at the end of the year. In so far as prices are volatile or subject to special temporary influences, it is not so much the price of the moment as the 'normal' price which is relevant. This, of course, introduces further difficulties of measurement. 'Normal' price is generally understood as an average over a period, but it can also mean the price that would obtain under certain conditions regarded as normal. Such an estimate of normal price is made, for instance, by the expert who values a business 'as a going concern'.

The problem of economic development and growth

Beside the construction of an articulate system of social accounts, current interest in the measurement of capital stems from its importance as a symptom and a cause of economic development. For this purpose capital is understood in the real sense. We are interested in a group of physical assets, called capital, as a factor of production and in the contribution it makes to output.

Most current work in this field is not concerned with the whole economy but with the industrial sector only. The chief reason for this concentration of interest is the relative ease with which statistics for the industrial sector can be obtained, but it is also true that some of the theoretical problems are less difficult in the industrial than in the other sectors of the economy.

There are two main approaches to the valuation of capital – identifying claims to assets and identifying physical objects. The former is eminently suitable when capital is conceived in the financial sense, but only the latter approach is possible when capital is conceived as a factor of production. This is an important qualification which implies a restriction on the statistical sources and methods available.

For the purpose of measuring real capital, we must form groups of physical objects rather than groups of claims to assets. One grouping is not readily translatable into terms of the other, for two reasons. First, the grouping of physical objects is accord-

ing to location but the grouping of claims according to ownership. Thus physical capital employed in an industry is not identical to the sum of claims of the owners of that industry; some assets may be rented from other sectors. Secondly, for business firms the market may provide a valuation of the total net claims of the firm, but this cannot be broken down according to physical objects: we cannot, for instance, infer from a stock-exchange quotation of a company's securities the value of its fixed assets.

The customary classification of capital is into fixed capital and inventories, but for many purposes it is more useful to revert to Adam Smith's fourfold classification distinguishing fixed capital, circulating capital, durable consumer goods, and perishable goods in the hands of the consumer. The last category is hardly measurable, nor is it analytically important to deal with it. Durable consumer goods include, on Adam Smith's definition, dwellings, and should also include all kinds of social capital, such as schools and hospitals. Circulating capital is then identical to inventories as commonly understood and fixed capital to structures and equipment other than dwellings and social capital. It is an advantage to keep these three categories – inventories, durable consumer goods and social capital, and other fixed assets – separate, since in many respects a different economic analysis is appropriate to each, and the problems of valuation and of measurement are also likely to be to some extent different.

The rest of the paper will apply specifically to the last category only, the tangible fixed assets of industry (in the broad sense). The problems of valuation and measurement arise in the most acute form in connection with this category of capital, partly because of the relatively long life of fixed assets and partly because of their enormous heterogeneity.

Almost all business firms compute balance-sheet values for fixed assets, although these figures are not necessarily published. The rules for these computations are determined partly by law, partly by accounting convention. In some instances firms compute more than one balance-sheet value; for example, depreciation for taxation may differ from the figure adopted by the firm for its own use. The principles by which the values are computed for taxation are generally known, although the resulting figures are generally not published for individual firms. On the other

hand, the methods used in arriving at published balance-sheet values are not always known.

In balance sheets – published or filed with the authorities – we have a mass of data which often tempts the statistician. For certain practical purposes balance sheet data are of real economic significance; for instance, taxation or governmental price fixing may be based on them. But it is doubtful whether these data are acceptable in studies of real capital.

There are two main reasons against the use of balance-sheet values. First, they are in terms of original cost (or, rather, cost of acquisition). Secondly, depreciation always tends to err on the conservative side, and in consequence a significant proportion of assets may not be represented in the balance sheet or represented at a value which is unduly low in relation to its cost of acquisition. The fact that occasional revaluations take place makes the task of the statistician more difficult rather than easier, because comparison between firms and industries becomes subject to further qualification.[1]

Balance-sheet values are relevant only in so far as they influence market values. As already mentioned, original cost does to some extent affect behaviour and thereby the market value of assets. If, for instance, price control based on original cost operates, this will depress the profitability and hence the market value of assets. In so far as business-men in reaching investment decisions take into account the original cost of old investment and accumulated depreciation provisions, this also would affect market values. But while these factors may help to explain price formation, they do not make balance-sheet values a suitable basis for measuring capital.

The obvious answer to the search for 'realistic' valuation is market price. The difficulty is that market price is not always available or, when available, is not necessarily accepted as typical.

In Western industrial countries a large proportion of industrial capital is valued on the stock exchange. Apart from a number of technical problems, there are three major difficulties in using stock-exchange quotations in the present context. First, prices are too sensitive to short-term influences, and averages

[1] A survey of the larger British industrial firms would suggest that the ratio between some 'realistic' value of fixed assets and published balance-sheet values varies enormously from firm to firm, industry to industry, and through time.

would have to be taken over rather long periods. Secondly, as already mentioned, stock-exchange prices reflect capital owned rather than capital employed in production, and an analysis of the total by type of asset is logically impossible. Thirdly, these prices reflect not only the value of physical assets but also the good luck or misfortune of the industry in which they are used and the efficiency of management.

Hence only the market for buildings and equipment can give guidance. As only a fraction of fixed assets are new, it is in fact the second-hand market which is relevant. This market can seldom give a readily acceptable quotation. In any reasonable period only a small proportion of assets passes through the market, or with many kinds of assets none at all, and there is always a suspicion that these are not typical of the classes which they represent. For most industrial assets there are very heavy costs attached to the transfer of ownership, and to a large extent the second-hand market represents exceptional cases, such as assets sold by bankrupt firms or by leading firms whose policy is always to have new assets. Moreover, second-hand prices are volatile, and a change from a sellers' to a buyers' market can bring about a disproportionate change in price.

Even though observed market prices are not always acceptable, in principle the equivalent of 'normal' price can be imputed. In everyday life such estimates are frequently made by experts for the purpose of, for instance, fire insurance, adjustments to the balance sheet, offers of purchase, or public price fixing. Balance-sheet values and recorded market prices are deceptively accurate. The expert, frankly, estimates or guesses, but this process may give results which are economically more significant.

The expert tries to estimate the market price that would obtain under certain hypothetical conditions. He assumes, for instance, that the transaction takes place as between willing seller and willing buyer. The study of the processes by which experts arrive at valuation opens up the possibility of obtaining a new source of economically valid data. One interesting instance is the study of legal cases involving disputes about valuation when the evidence of experts is available to the public.[1]

This type of valuation, which seems to be the only satisfactory

[1] For an excellent example of such studies, cf. J. C. Bonbright, *The Valuation of Property*, New York, 1937.

one for the measurement of real capital, is discussed more fully in the next section.

III. SURVEY METHODS

Estimates of capital are generally based on published statistics of capital formation, on published balance sheets, or on calculations of physical capacity and costs of construction. The direct method of collecting data for the specific purpose of measuring capital is seldom used. Such data are, however, available, since they are needed in everyday affairs.

Economic theory provides the general formula for rational valuation: the value of an asset is equal to the sum of the discounted future income stream expected from it. This formula focuses attention on expectations, which are subjective, and on the fact that the future is always discounted compared to the present. But the application of the formula is not generally practicable. Men of affairs do not use formulae; this is just the economist's way of rationalizing their implicit methods.

The general method followed by the expert is to estimate replacement cost, and this can be done in two steps. First, he estimates the cost of replacement with a brand-new asset and, second, he makes an allowance for age, wear and tear, and obsolescence. The difficulty is that replacement, if it were to take place, would not be by identical units. As a result of inventions, capital undergoes an almost continuous and steady improvement, and hardly any two assets produced at different times are identical. The expert has to find a modern substitute for the existing asset and has to take account of differences in the profitability of the two types of asset. Lastly, when he takes age into account, he has to look forward and estimate the likely future life of the asset, rather than look into the past to determine expired life. Expert valuation is an art which consists of finding the amount of new and modern assets which is the equivalent of the old and obsolete asset in the economic rather than in the engineering sense. Different experts will, of course, arrive at different results, but this is no more than to say that the estimates are subject to error.

Replacement cost should include, in addition to the cost of acquisition of assets, also the cost of installation and other incidental costs. There is an important difference between the value of assets as installed in certain relation to each other and

the break-up value when each asset might be sold separately. For our purpose assets should be valued at their worth to the existing management on the assumption that they want to continue in business.

The estimate also depends on the units into which assets are divided for valuation, and it is a recognized principle of property valuation that the value of the sum total of assets may differ from the sum total of the value of each asset. A machine consists of different parts which wear out at different times; the life of the machine may well be determined by a relatively short-lived component. If the lay-out of a factory is obsolete, its value may even be less than the break-up value. On the whole, however, the value of a complex unit is higher than that of its component parts because of the labour necessary to create the complex. The choice of a suitable unit for valuation is important in, for instance, valuation for fire insurance. This is especially so in modern factories, where the insured is more concerned with the possibility of partial loss than with total destruction. The usual practice is to value neither a whole factory or workshop as a unit, nor the smallest possible items, but something intermediate, such as a machine with all its attachments or a complex plant which operates as a single entity.

It was stated that the expert, in general, makes his estimate in two steps: he estimates the cost of a new asset, which is then adjusted (written down) to take account of the actual state of the asset to be replaced.[1] Hence two different concepts of replacement cost are distinguished: the cost of replacement with new and the cost of replacement with second-hand assets. It is the second concept which corresponds to the value of capital in economic theory, but the first has great practical importance. Very often experts estimate *replacement cost new* only. Sometimes, when the asset is near the end of its useful life, they estimate *written-down replacement cost* (which is a better term than 'net replacement cost') directly, without taking two separate steps.

Replacement cost new sets an upper limit to replacement cost, as it is normally possible to replace by new assets, though, exceptionally, an allowance must be made for scarcities (when the asset is not readily obtainable at the ruling price). The

[1] The rate at which the expert writes down new assets is not necessarily identical to the conventional rate of depreciation.

manufacturer would clearly be better off, apart from the disturbing effects of the change, if he were to replace old assets by new.

The value of assets declines with age partly because the expectation of further life declines and partly because of falling efficiency (in an economic or in a technical sense). It logically follows that value declines faster than efficiency, and indeed for important classes of assets efficiency does not decline at all. For this reason replacement cost new is a useful concept when examining the relationship of assets to current output, and certainly more relevant than written-down replacement cost in forecasting requirements of incremental capital.

One particular purpose for which replacement cost is estimated is fire insurance. The estimate of the insurable value can be the result of an elaborate procedure by experts or simply a guess by the business-man. This valuation ought to be realistic, and in the great majority of cases it is, as on its appropriateness the survival of the firm may well depend.

Since fire insurance is general, it is a possible source for statistical data. This was realized for a long time, as evident, for instance, from the interest shown in fire-insurance statistics by the St. Petersburg Congress of the International Statistical Institute in 1872. But to be able to interpret fire-insurance statistics, a direct survey of insurance policies is needed.

In a project into the measurement of capital in British industry at the National Institute of Economic and Social Research in London the empirical problem was tackled in two stages, corresponding to the two steps of the expert valuation process. In the first stage the replacement cost new of fixed assets was investigated, and in the second the length of life of assets and their declining efficiency with age. In the first stage a sample inquiry into replacement cost was undertaken and its chief results are shown in Table I.[1]

The inquiry concluded that the valuation of fixed assets for fire insurance does give a good basis for estimating, in an economically significant sense, the value of assets. But the figures which can be obtained from manufacturers are meaningless without an adequate explanation of the basis of valuation

[1] For a full account of the inquiry cf. T. Barna, 'The Replacement Cost of Fixed Assets in British Manufacturing Industry in 1955', *Journal of the Royal Statistical Society*, Series A, 1957.

and of the coverage. In certain instances supplementary information is required on uninsured assets and on the degree of under-insurance. Uninsured assets are confined to a small number of industries, and the problem was by-passed through obtaining insurable (as against insured) values and other estimates of replacement cost. Some firms disclosed the degree of under-insurance and, in general, under-insurance is unlikely to have greatly affected the results. This is so because small firms, which are more likely to under-insure, were not sufficiently represented in the sample and also because firms who were aware of defects in their insurance valuation tended to refuse to participate in the inquiry.[1]

The second stage of the inquiry, into the life of assets, aims mainly at the description in qualitative terms of the relevant characteristics of assets, but a certain amount of statistical data was also collected from a sample of firms (which is not necessarily representative for British industry). The statistics collected can be translated into terms of demographic statistics – life tables, mortality rates, average expected life, age distribution, etc.[2]

The questions asked seek to obtain information on the life of assets: (a) as implied in the firm's depreciation policy, and (b) as shown by past experience. Although the past is not necessarily a guide to the future, the returns received invariably indicated that assets acquired in the past lasted significantly longer than implied in depreciation policies.[3]

IV. VOLUME INDEXES

The problem of splitting changes in the value of capital into changes in price and changes in volume is the general index-number problem in a very acute form. This is so because of the great heterogeneity of capital assets. A given commodity can be produced by more than one technique, each employing a different set of equipment, and, moreover, assets of the same type differ in age, and this makes them different from an economic point of view even if measurable physical wear and tear is negligible. But the real difficulty is that because of technical

[1] On the nature of fire insurance, see also Appendix A below.
[2] A full report on this stage of the inquiry is not yet available.
[3] It should be noted that, as regards assumptions for the length of life of assets, on the whole, company depreciation policies do not differ substantially from normal tax depreciation.

TABLE I

Replacement Cost New of Fixed Assets in Manufacturing, United Kingdom, Mid-1955

Standard Industrial Classification Minimum List Heading	Industry	Employment 000's	Employment on Sample Returns %	Total Fixed Assets			Fixed Assets per Person Employed			Error in All Fixed Assets p.h. £
				Buildings, etc. £ million	Plant, etc. £ million	All £ million	Buildings, etc. £	Plant, etc. £	All £	
21	China and earthenware	73	78	23	22	45	310	310	620	100
22, 23	Glass	77	3	42	50	92	550	650	1,200	200
24	Cement	13	31	20	20	40	1,570	1,530	3,100	300
	Other	159	8	118	146	264	740	920	1,660	200
Order III	Treatment of non-metalliferous mining products	322	24	203	238	441	630	740	1,370	110
30	Coke ovens	20	5	20	158	178	1,000	7,900	8,900	1,000
31, 33	Chemicals, etc.	203	43	199	869	1,068	980	4,280	5,260	600
32	Drugs and toilet preparations	64	17	52	50	102	810	790	1,600	300
34	Paint and varnish	40	16	32	27	59	790	680	1,470	100
35(i)	Soap, etc.	23	44	24	38	62	1,040	1,660	2,700	300
36	Mineral oil refining	18	96	67	170	237	3,760	9,590	13,350	500
	Other chemicals	47	24	49	41	90	1,040	880	1,920	300
Order IV	Chemicals and allied trades	415	34	443	1,353	1,796	1,070	3,260	4,330	300
40, 41, 43	Iron and steel	276	33	216	791	1,007	780	2,880	3,660	300
42, 44	Foundries, tubes, etc.	171	1	86	188	274	500	1,100	1,600	300
49	Non-ferrous metals	113	30	119	164	283	1,050	1,450	2,500	400
Order V	Metal manufacture	560	23	421	1,143	1,564	750	2,040	2,790	190
50	Shipbuilding	223	—	89	112	201	400	500	900	400
51, –69	Mechanical engineering, etc.	990	5	455	1,030	1,485	460	1,040	1,500	300
70–79	Electrical engineering, etc.	800	29	376	512	888	470	640	1,110	100
Order VI	Engineering, etc.	2,013	14	920	1,654	2,574	460	820	1,280	160
80, 82, 83	Motor and aircraft	647	23	394	788	1,182	610	1,220	1,830	200
	Other vehicles	248	—	124	124	248	500	500	1,000	300
Order VII	Vehicles	895	16	518	912	1,430	580	1,020	1,600	170

Orders VIII and IX	Metal goods, n.e.s., precision instruments	608	5	255	414	669	420	680	1,100	200
113	Rayon, etc. production	38	80	62	112	174	1,630	2,940	4,570	200
	Other textiles	902	6	1,100	1,342	2,442	1,220	1,490	2,710	400
Order X	Textiles	940	9	1,162	1,454	2,616	1,240	1,550	2,790	380
Orders XI and XII	Leather, fur, clothing, etc.	641	3	257	192	449	400	300	700	200
150	Grain milling	37	4	66	117	183	1,770	3,170	4,940	500
151	Bread, etc.	215	6	133	132	265	620	610	1,230	200
152	Biscuit	60	11	24	25	49	400	420	820	200
155	Sugar and glucose	19	76	28	75	103	1,470	3,950	5,420	200
156	Cocoa, chocolate, etc.	105	12	73	82	155	700	780	1,480	300
	Other food industries	219	10	182	243	425	830	1,110	1,940	400
163–168	Drink industries	138	1	310	242	552	2,250	1,750	4,000	600
169	Tobacco	37	87	30	30	60	810	820	1,630	100
Order XIII	Food, drink, and tobacco	830	13	846	946	1,792	1,020	1,140	2,160	160
Order XIV	Manufactures of wood and cork	276	1	138	110	248	500	400	900	200
180, 181	Paper and pulp	88	22	123	291	414	1,400	3,300	4,700	300
182, 183	Cardboard and paper products	109	17	81	107	188	740	980	1,720	200
186	Newspaper printing	112	10	69	146	215	620	1,300	1,920	300
189	Printing	210	4	141	189	330	670	900	1,570	300
Order XV	Manufactures of paper	519	11	414	733	1,147	800	1,410	2,210	150
190	Rubber	110	33	55	138	193	500	1,250	1,750	100
	Other manufacturing	131	1	83	98	181	630	750	1,380	200
Order XVI	Other manufacturing	241	16	138	236	374	570	980	1,550	120
Orders III–XVI	Total manufacturing	8,260	13·4	5,715	9,385	15,100	690	1,140	1,830	70

development the nature and quality of capital equipment is constantly changing, and this process is irreversible.

In measuring the volume index of a bunch of commodities we generally rely on the fact that there are situations in which the prices of the commodities constituting the bunch are comparable, and it is on this basis that Professor Stone devised a basis for allowing for quality change.[1] With capital, however, the chief difficulty is that such situations do not exist, and cannot exist unless the technique of production of each industry were fixed, because quality change is not a reversible process, though for some consumer goods it is. Professor Stone also assumes that more than one quality of a given commodity is marketed at the same time, which is likely to be so in the case of consumer goods, where the market provides for the differing tastes of the public, but less likely in the case of capital goods, which are purchased not for subjective reasons but to make profit; here the latest model completely supersedes the earlier one, except during a transitional period when price comparisons might be misleading.

If we compare two economies, the sets of equipment used are likely to be different in them precisely because economic circumstances are different. If technological knowledge is the same in the two economies, the chief determining factors in the choice of equipment are real wages and the rate of profit ruling in the economy. Comparison is possible only if we revalue capital in one country on the assumption that the real wages and the rate of profit of the other are ruling – and this, of course, may lead to absurd results.

If, on the other hand, we take the same country at different times, technological knowledge has changed, bringing in its train changes in real wages and/or rates of profit. The difficulties are there again. Comparison is only possible through imputed prices and not by measurement of market prices. Even if the out-of-date and the newly invented equipment are produced simultaneously, this will be during a transitional period when relative prices represent neither relative costs nor relative value to the user but something between the two.

It is clear that if we make comparisons either between economies or through time, the outcome will be different according to whether we measure capital in terms of resource inputs or in

[1] R. Stone, *Quantity and Price Indexes in National Accounts*, O.E.E.C., 1956.

terms of final output – in terms of effort or in terms of efficiency. The more primitive economy has to make a greater effort to produce a given result.

Capital in terms of investment effort – that is, accumulation in the classical sense – ought to be measured by a value index deflated by a cost index. The chief constituents of the cost index are wage-rates and the rate of interest or profit.[1] The rate of interest affects the cost of brand-new equipment, since this required other, already existing, equipment for its production. Further, the rate of interest also enters the formula which relates equipment of a given age to the cost of brand-new equipment of the same type.[2]

Capital in terms of productive efficiency, on the other hand, should be measured as a refined volume index which takes account of improvements in 'quality'. But while such an index for consumer goods can be attempted with reference to market prices, for capital it must, in general, be imputed. We require a set of technical data, wages, and interest rates to compare one technique with another.

There are, then, two main alternative measures of the volume of capital – capital conceived in terms of effort or in terms of efficiency. It is not possible to compromise between the two, since technical progress, by its very nature, continually widens the gap between them. For different purposes we need a different concept, and it should prove useful to compute both indexes.[3]

A survey of econometric literature indicates that the chief attempts which have been made to measure capital were neither in terms of input nor in terms of output, but, somehow, in terms of its own 'price'. To compute a price index for capital goods is not easy – partly because it is not clear what such an index should measure – and often very primitive calculations (such as price per ton of machinery) are incorporated. The authors, as far

[1] The cost of materials can also be resolved into wages and interest or profit.

[2] For the solution of the index-number problem, which arises from the need to take account of both wage-rates and interest, Professor Champernowne suggested a chain method.

Mrs. Joan Robinson, on the other hand, is more inclined to deflate by wages only. The latter is admittedly a cruder method, but it is much simpler, and it is probable that not much is lost in accuracy. It can be argued that in the most interesting comparisons the differences in wage-rates are large but in rates of profits perhaps not. See articles by D. G. Champernowne, R. F. Kahn, and J. Robinson in *Review of Economic Studies, 1953–54*.

[3] I did not mention other indexes – such as the index of capacity – which are one-dimensional and do not take account of the economic essence of capital.

as can be seen, do not correct for 'quality change'. In other words, the index of the 'price of capital goods' implicitly takes account of inventions which reduce costs in the first instance in the investment-goods sector but not of inventions which reduce costs indirectly in the consumption-goods sector. For obvious reasons the movements of such an index must be between those of the two other indexes.

V. AN INDIRECT METHOD

The direct method of comparison is to take the value of capital in two situations and to correct for price differences. The so-called perpetual-inventory method, which was pioneered by Dr. Goldsmith in the United States, achieves the same end indirectly.[1] Here one takes capital formation year by year, corrected for price changes, and then the figures are cumulated and suitable deductions are made for capital consumption. The conceptual problems connected with the basis of valuation and with the price deflator, which were discussed in previous sections of this paper, are present but perhaps less easily recognized. All in all, the perpetual inventory method differs from the direct method only as regards statistical technique. The method was developed and used to exploit readily available statistical data. It suffers from the disadvantage of all indirect methods of measurement that its results may be subject to large error.

The method estimates both replacement cost new and the written-down replacement cost of capital, and changes in their volume over time. The results obtained depend on: (a) annual statistics of capital formation; (b) price index-numbers for capital, and (c) estimates of the length of life of assets. The conceptual problems are subsumed in the type of price index used, which was already discussed at the end of the preceding section.

The quantitatively crucial factor in the method is the estimate of the length of life of assets. In the United States the estimates of Dr. Goldsmith, and more recently of the Department of Commerce, and in the United Kingdom those of Mr. Redfern,[2] are based on lives implied in typical (but not universally adopted) depreciation rates for income-tax purposes.

For the United Kingdom I could adjust Mr. Redfern's esti-

[1] R. W. Goldsmith, 'A Perpetual Inventory of National Wealth', *Studies in Income and Wealth*, Vol. 14, N.B.E.R., New York, 1951.

[2] P. Redfern, 'Net Investment in Fixed Assets in the United Kingdom, 1938–1953', *Journal of the Royal Statistical Society*, Series A, 1955.

mates to make them comparable with my own estimates, which are based on the direct method. The disturbing gap between the two estimates is shown in Table II. The dividing line between buildings, on the one hand, and plant, on the other, is not unambiguous, and too much attention should not be paid to the separate figures. The error in my estimate due to sampling and the errors in my adjustments to Mr. Redfern's estimates are, probably, of a smaller order of magnitude than the gap between the two sets of figures. As regards conceptual differences, these tend to cause a gap in the opposite direction to the one actually found.

TABLE II

Comparison of Two Estimates of Fixed Assets in Manufacturing, United Kingdom, Mid-1955

(in £ thousand million, 1955 prices)

	Buildings	Plant and Machinery	Total (exc. vehicles)
Redfern [1]	3·5	6·6	10·1
Barna [2]	5·8	9·5	15·3
Difference as percentage of Redfern	66	44	51

[1] Original coverage increased to include: (a) factories built by the Government during the War and now leased to private firms, and (b) assets for government research and development.

[2] As in Table I, plus Atomic Energy Authority.

The discrepancy is thus due to statistical factors which include, in order of importance, the following:

(a) The length of life of assets is longer than implied in the income-tax depreciation rates, and this is consistently confirmed by the results of more recent research.

(b) Capital formation is under-reported in annual statistics. In general, a proportion of assets is charged to revenue, and such assets are not represented in statistics of capital formation but are included in estimates based on a direct inventory. A unique instance is the subsidy element in private capital formation, which is the result of government-financed asset creation during the War; this, itself, might explain one-fifth of the gap shown in the table.

(c) Statistics of capital formation are subject to the usual statistical errors, which might have been important in the earlier years utilized by the perpetual-inventory method.

It is probably true to say that the perpetual-inventory method is subject in all countries to the same kinds of error as in the United Kingdom, though it is difficult to generalize about the magnitude of these errors.

VI. CONCLUSIONS

In recent decades the popularity of national-income estimates far exceeded that of estimates of national wealth. This was not so in the eighteenth and the earlier parts of the nineteenth centuries, when estimates of the national wealth were frequently made and the 'strength of nations' was often compared in terms of capital rather than in terms of output.

The inherent difficulties in measuring national capital are obvious. The logical difficulties are equally present in the measurement of national income (taken as the equivalent of consumption *plus* additions to the stock of assets) but are, quantitatively, far less important. It is probably true to say that individual income is more difficult to define and measure than social income, but social capital is a more difficult concept than individual capital, which represents an individual's share in total wealth.

But there are also deeper reasons for the fluctuating fortunes of estimates of capital, and these derive from changing emphasis in economic policies and in economic theory. In the eighteenth and early nineteenth centuries the use of national wealth, as against national income, estimates was not unconnected with economic theories, which assumed that wages were determined by the subsistence level. In these theories the cost of labour is fixed, and labour itself is produced by the system in the same way as commodities are produced. The aim of the economy is to maximize the surplus produced over the cost of materials and labour. National capital is not an unsatisfactory measure of the results of this activity, and in many respects it is a better measure than the sum of capitalist incomes (rent, interest, and profits), since it includes durable goods which yield no money income (such as furniture, jewellery, and precious metals).

With the growth of interest in the standard of living of the people, attention became concentrated on estimates of national income. The main purpose of statisticians, for many years, was social rather than economic. The deliberate construction of national-income estimates for purposes of economic analysis became customary only in the inter-war period, and received its

final impetus during and after the last war. The system of national-income accounts, as we have come to know it, is intimately connected with the economic problems of the developed Western countries in the last twenty-five years and with Keynesian economic theory. In fact, the system of accounts is, ultimately, a statistical analogue of the Keynesian fiscal policy model. The chief purpose of this model is to prescribe fiscal policies for curing either unemployment caused by lack of demand or inflation caused by excess demand for resources.

There are limitations of this approach in two main directions. First, the national income accounts are in themselves insufficient when one is dealing with problems requiring monetary as against fiscal policy measures. Secondly, they are obviously insufficient in dealing with problems of economic development which have become one of the pre-occupations of contemporary economics. In both instances we require capital as well as income estimates. In the first instance we require estimates of claims and liabilities, that is estimates of capital understood in terms of finance. In the second instance we require estimates of 'real' capital. These estimates are required not in substitution of estimates of income but as a complement to them.

The chief difficulties with studies of real capital are partly conceptual and partly statistical, although the two kinds of difficulties interact. The purpose for which estimates of real capital are needed must be explicitly stated, since different purposes require a different approach. On the statistical side there is need for direct and more detailed studies of capital and its effect on productivity.

A particularly undesirable possibility is the use of estimates for developed Western countries, which are either inaccurate or prepared for a different purpose, for the planning of economic development in other countries. Clearly a structural analysis, if necessary based on detailed engineering data, should be superior to the much-abused method of indirect statistical inference.

APPENDIX A

NOTE ON FIRE INSURANCE

A fire policy is a contract whereby the insurer undertakes to compensate the insured for direct losses incurred in the event of fire. There are a number of different types of policy but, in the United Kingdom, they commonly embody the following principles:

(i) The policy gives cover for the destruction or physical deterioration of assets and not for consequential losses due to fire damage: production may be interrupted as a result of fire and profits may consequently suffer, but this loss is not covered by a fire policy. Another policy may be taken out to cover for loss of profits, including such items as the salaries of a nucleus staff and prestige advertising while production is interrupted, but such policies need not concern us here.

(ii) It is universal practice to place a definite value on the assets insured, the determination of this value depending on the type of policy.

(iii) In the event of fire the insured cannot receive more than full compensation, in terms of a given policy, even if he has placed an excessive value on the asset; but he can be under-compensated if he has placed an insufficient value on the assets.

Generally, fixed assets are specified separately from stock, and the technique of valuation is also different for the two types of assets. Seldom is a detailed list of items attached to the policy, but more commonly a factory is insured as a whole, specifying separately buildings and plant. In larger factories there is a tendency to insure by zone. There is also a tendency on the part of the insurer to insert the 'average' clause in certain types of policy under which all parts of a whole are deemed to be valued on the same basis. This means that if in the event of a loss the value insured is less than the true value, the insured is required to bear a proportionate part of the loss himself. In other words, if the rate insured is £10,000, the true value £20,000 and the loss £4,000, then the insured can only recover £2,000.

Two main types of policy exist: insurance for reinstatement and insurance for indemnity. The values to be insured under the former type correspond to replacement cost new. Under the latter type current market values are insured: in fact, the most frequent procedure is to determine current values as equivalent to written-down replacement cost. The choice between the different types of policy is left to the insured. He may, of course, always replace items lost with new assets, but under an indemnity policy he would not recover the full cost.

The insured generally excludes assets which he regards as indestructible. Apart from land, foundations to buildings fall into this category: they may account for 7–15 per cent of the value of buildings. Most other uninsured assets are in heavy industry, and include roadways, railway sidings, blast furnaces, coke ovens, and similar assets which are not inflammable. The extent to which these assets are in fact indestructible is debatable. Cases are known when foundations have cracked as the result of fire and had to be replaced at great cost. Properly, the values insured ought to allow even for the demolition of damaged buildings and for the clearing of debris. The practice of excluding so-called indestructible assets varies from firm to firm, but the impression was gained that the majority exclude foundations to buildings.

In industries where a significant proportion of assets, if not the bulk, is uninsured, fire-insurance values would give a misleading indication of the value of fixed assets. Fortunately, in most of such cases firms are able to supply information on the replacement cost of all fixed assets, whether insured or not. Indeed, it appears that an increasing number of firms is interested in possessing information on the replacement cost of assets quite apart from the need for such information for fire insurance. These figures are used for estimating depreciation in excess of normal balance-sheet depreciation and for assessing the profitability of the business in relation to real capital employed. Only a few of the firms possessing this information did revalue assets in the balance sheet.

Whether for fire insurance, or for other purposes, the technique of valuation can be divided into three categories:

(i) A detailed valuation may take place based on an expert assessment of physical assets either by a firm of valuers or by the manufacturer's own engineers. This procedure is slow and expensive, and takes place only infrequently.

(ii) The replacement cost of assets may be estimated by finding in the records the cost of acquisition and the date of purchase of each item, and by applying price indexes to bring these values up to date. The price indexes may be general or specifically prepared for the firm, and may or may not differentiate between different types of assets.

(iii) Short-cut methods may be used for bringing previously established values up to date by applying some index of prices.

In principle, policies are annual, but values insured are altered in the course of the year as additional assets are acquired or sold. It is not customary to make changes during the year to allow for the effect of changing prices, but such changes should be made annually.

It is known, however, that the latter kind of change is not made as regularly as it should be, and the valuation, especially of the smaller enterprises, is often brought up to date only once in several years.

The question of under-insurance is the most difficult to discuss. Over-insurance may perhaps be ignored, as the insured is not allowed to benefit by it: over-insurance, if it exists, is due to errors in valuation rather than to choice. But many firms are known to under-insure in order to save on the premium. Although rates are differentiated according to trade, and whether or not the factory has a sprinkler system, many insured feel that in their particular case the risk is less than is implied by the rate. An important element in the manufacturer's own judgment is the consideration of total loss, and therefore close attention is paid to factors such as the location of the factory (in relation to water supply or fire brigades) and the closeness of workshops to each other. For a large firm the wisest course is to prepare a good valuation of assets and then try to obtain a reduction in the rate, but this way may not be open to a small firm. Some firms under-insure by a given percentage with the express approval of the insurer. Here the difficulty can be overcome by asking for insurable values rather than for the actual sums insured. The problem is really confined to firms who under-insure in relation to the provisions of the policy. It should be made clear that the insurer is not trying to discover whether or not manufacturers under-insure so long as no fire takes place, and in the event of fire he would reduce the claim in proportion to the degree of under-insurance.

The existence and often the extent of under-insurance can be discovered by questioning the insured on the technique used to arrive at valuation. Under-insurance must be understood, of course, strictly in relation to what is meant to be insured, and account must be taken of:

(a) the basis of valuation, whether for reinstatement or for indemnity;
(b) how far certain types of assets are not covered; and
(c) the method of appraisal.

For instance, an insured having a reinstatement policy and assets only a few years old may insure original cost even though the cost of replacement has risen since he bought the assets. He may exclude foundations and make an excessive deduction for them. But more generally, in a period of rising prices values are not regularly revised upwards, or revised by only an insufficient percentage. Some firms, even though they have a reinstatement policy, assume that the annual rise in prices just about offsets the depreciation of assets through age. Others add 50 per cent to pre-war values instead of 300 per cent. The largest firms employ at least one clerk whose business is to report to

the insurer the acquisition of new assets, and policies are frequently revised, pretending to accuracy; yet the policy may be substantially different from the correct value. The impression gained is that in a number of instances manufacturers take out a reinstatement policy and in the course of time allow it to approach the value of an indemnity policy, without, however, explicitly admitting this.