Measuring capital
and the length of life of capital goods

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The purpose of this paper is to give an account of the work in the
field of measuring capital which we have been doing at the National
Institute of Economic and Social Research in London. We were
concerned with the measurement of capital understood as the money
value of tangible assets-buildings, plant and machinery. Perhaps
it is not necessary here to explain why we wanted to measure
capital; there are several good reasons for it. Capital is an important
factor of production and before we can make any statement relating
to the efficiency of utilisation of resources, we must know in
quantitative terms how much capital is employed in production.

In our work we were interested chiefly in broad comparisons
between industries; in other words we were concerned with the
problem of measuring capital from the social point of view. This
kind of measurement is necessary if one wishes to compare the
productivity or efficiency of one industry with another, or the pro-
ductivity of an industry to-day with that five or ten years ago. But
the problem of measuring capital from a private point of view is
exactly the same. A large and complex firm, which has several
factories or is engaged in several industries, must make comparisons
between its different constituent units. It must judge its managers
and must consider the profitability of the different units and for
this purpose it must have some quantitative evaluation of the amount
of capital engaged in production.

Let me begin with two negative statements, explaining what we
did not do.
First, we did not measure capital in terms of physical units. There exist of course measures of physical capacity in industries like steel and electricity but we were not interested in these. There are a number of technical reasons why in most industries it is very difficult, if not impossible, to measure capacity. In general, it is not possible to have an inclusive physical concept for the total capital stock of an industry and of course comparisons between one industry and another are possible only in terms of money. The concept we are interested in is essentially an economic concept which must be expressed in monetary units.

Secondly, we did not measure capital with reference to the published balance-sheets of companies although we are in a relatively fortunate position in the United Kingdom because much of British industry is run by joint-stock companies which are obliged to publish balance-sheets. The proportion is about one-half for manufacturing as a whole but much more for industries like steel and chemicals which are intensive users of capital. Moreover, the Companies Act of 1948 has improved the contents and the presentation of balance sheets. But, although company accounts are as intelligible and consistent from year to year as in any other country, they are (as everywhere) highly imperfect as regards the valuation of fixed assets.

Balance sheets are approximately satisfactory as regards working capital and liquid assets; there are of course problems connected with the valuation of working capital but in manufacturing industry the problem of valuing fixed assets is quantitatively far bigger. The valuation of fixed assets is generally at original cost which in a period of inflation, such as we have had for the past 25 years, means that we cannot compare one company with another, or one industry with another. Further, assets are depreciated, in general, faster than they actually wear out. Within limits, companies can adopt any method of depreciation, provided consistency is maintained in the accounts. All this implies that balance-sheet values for fixed assets are unrealistic and the extent of this varies from company to company in a manner which cannot be assessed without inside information.

I should add that published company accounts are not necessarily identical to accounts submitted to the Inland Revenue for purposes of taxation. The rules for taxation are more rigid and consequently accounts as between different companies are more consistent; but these accounts are not published either for individual companies or in the aggregate.
In the event, we held discussions with a selected number of companies to discover whether in their own thinking they use concepts which are more realistic than those used in balance sheets. We soon found that there are such concepts and that these concepts fall under the heading «replacement value of assets». We found that business firms have a very good idea about the realistic value of fixed assets they possess. Not all business firms of course, and perhaps not even the majority, but enough (and an increasing number) to give us information from which valuable generalisations can be derived.

I must emphasise that what I call realistic valuation is not an accurate valuation but an estimate. This is in contrast to figures in balance sheets which carry sometimes nine digits. But it is clear that a rough estimate on the correct principles is better from our point of view than an apparently exact figure computed on the wrong basis.

One purpose for which most companies make a realistic valuation of assets is fire insurance. The question they ask is: what would it cost to replace assets in case of a fire? We asked companies for their fire insurance valuation and also for an explanation of the method by which they arrived at the estimate. Frequently they gave us, instead of the fire insurance figure, some other estimate of replacement cost which they thought was better for our purposes. In fact a realistic value of assets can be obtained only through direct contact with business and often only after discussion of the nature of the estimates available. We think that in the end we arrived at concepts which are realistic and for which statistical information can be obtained.

It emerged that there are, broadly speaking, two different concepts of replacement cost: the cost of replacement with new assets and the value of old assets in their existing state. The value of old assets is of course less than the value of the corresponding new assets. I called these two concepts «replacement cost new» and «written down replacement cost». This also corresponds to the two main types of fire insurance policy which appear to exist in the United Kingdom. A company can insure either for reinstatement, that is replacement of productive capacity with new assets, or for indemnity, that is compensation for the actual value of assets.

It is difficult to define replacement cost new in precise terms as one hardly ever replaces with identical assets. This is especially true for buildings and larger units of plant where there is constant improvement of layout and design. Hence it is difficult to lay down exact rules for valuation. But people who do valuation in
practice make an instinctive allowance for this and the results are broadly acceptable from the economist's point of view. Our concept of replacement cost is not the cost of replacement with identical assets but with some new assets which are economically equivalent to the old as they originally were.

Valuation is frequently done by professional valuers though larger firms often employ their own engineers for this purpose. Professional valuation is a science with which unfortunately economists have little connection. It is a science worth studying because one can discover, especially from a study of controversial cases, the principles on which practical people act when confronted with the issue of putting a value on capital assets. In the United States, for instance, public utility rates are fixed in relation to the value of assets and expert evidence in courts of law forms useful material for studies of the principles of valuation.

In our study useful information was obtained from 90 firms. This is a relatively small number but they are estimated to represent in the aggregate one-sixth of manufacturing capital. We are satisfied that these firms were a representative sample of British manufacturing, and that the information obtained was reliable. It so happened, however, that we obtained good information on replacement cost new but not enough material on written-down replacement cost.

Chart 1 shows, for 36 sectors of manufacturing, the replacement cost new of assets per employee and value added per employee. Assets here include both fixed assets and inventories. The value of fixed assets is obtained from our sample inquiry and that of inventories and of value added from the Census of Production. The figures used are of course imperfect both statistically and conceptually. They are imperfect statistically because asset values were derived from a sample and they are imperfect conceptually partly because we cannot define capital value precisely and partly because our value added figures include various business costs (such as advertising expenditure) which properly ought to be excluded.

There are two important conclusions exhibited by the chart. First, it shows a wide variation between industries in the amount of assets per employee. Secondly, it shows a correlation between assets per head and value added per head.

We can distinguish three types of industry characterised by different levels of assets per head. At the upper end we have the highly capitalised industries with assets per head exceeding £ 3,000 or £ 4,000; for oil refineries the figures are near £ 15,000. These figures are of course for whole industries but in any industry there can be big differences between successive processes of production.
CHART 1

Value added and assets per employee in different manufacturing industries,
United Kingdom, 1954

(This chart is taken from Journal of the Royal Statistical Society, 1957,
Series A: Part 1, p. 26)

Value added
£'000

Assets
£'000

1: Cement. — 2: Tobacco. — 3: Rayon. — 4: Beer, spirits, etc. — 5: Grain,
milling. — 6: Sugar. — 7: Other chemicals. — 8: Soap. — 9: Drugs and
metals. — 17: Other food. — 18: Motor and aircraft. — 19: Bricks, etc. —
In a paper factory, for instance, I have seen machines worth hundreds of thousands of pounds worked by four people but at the end of the line writing paper was sorted by hand. In arriving at industry averages the ancillary processes are just as important as the primary ones.

Industries with a high average capital per head have certain characteristics: the processes are flow processes where production goes on continuously. Technically paper is very different from steel or non-ferrous metals. But from our point of view the capitalisation of these industries is about the same and the processes are fundamentally similar: in each case the most important part of the plant consists of a set of large rollers.

At the bottom of the scale we have industries with a low degree of capitalisation which have only recently emerged from the handicraft stage. There are no proper handicraft industries in the United Kingdom any more and those which were 20 or 40 years ago based on handicrafts are now mechanised and producing for a mass market. The clothing and furniture industries are typical of those which underwent a revolution during the war. They could not survive in the old form, they had to mechanise but mechanisation cannot go as far as in the capital-intensive industries. They are essentially working on batch production and not on flow production.

About 10 per cent of the total manufacturing labour force is in industries in the top group and another 10 per cent in the bottom group. The bulk is in the middle-range industries of the engineering type, with a good degree of mechanisation but nothing like approaching flow production of standardised commodities.

These findings of differences between industries are very important from the point of view of studying the behaviour of industries and their attitude to capital. Obviously at the top end of the scale capital is important and labour is not, while a the bottom of the scale capital is unimportant. Here it is more important to sell the product than to have good machinery to produce it. In the clothing or furniture industry one can say that they have to sell the product before they produce it. Once salesmanship is successful there is no difficulty about installing machinery as required. But in the steel or paper industries equipment is very heavy; it may last 50 years and it may take several years to design and to instal. Here it is customary to work three shifts a day and wages can be more generous.

The chart also shows, as already mentioned, the correlation between capital per head and value added per head. The two elementary regression lines are indicated and the « best » estimate
of the relationship (that is, taking account of the relative size of errors in the two variables) is a slope of 15-20 %. In other words gross profit (before depreciation and before tax) was in the region of 15-20 % of gross (undepreciated) capital on a replacement cost basis. Net profit on net capital (both after depreciation but profits before tax) would come according to some rough estimates to near 20 %. This order of magnitude is confirmed by direct inquiries since this is the rate of profit at which businessmen generally aim when making investment decisions. The important conclusion is that the ruling rate of profit in industry is of a different order of magnitude from the 5 or 6 % rate at which industry can borrow from the banks. But the figure is consistent with stock exchange behaviour where a dividend yield of 5 to 6 % covered by earnings three of four times was excepted in that period.

I regard the replacement cost of assets per employee as one of the chief indications of the intensity of capital in an industry. Our inquiry has shown that this factor varies from £ 500 to £ 15,000 inside British manufacturing. But capital is a multi-dimensional concept which cannot be described by one variable alone. Another factor I consider important is durability by which I mean the period during which capital is effectively used in production. We have therefore initiated another inquiry in order to measure this second factor.

Several studies have been made in the United States, and one a long time ago in Germany, into the length of life of various assets. But all these studies deal with particular types of assets, mainly those in the public utility sector such as telegraph poles or railway rolling stock, and we also have studies for motor vehicles and for ships. It is difficult to believe that these items are representative of the general run of industrial capital. Manufacturing industry is characterised by a very wide range of equipment and one cannot possibly study each type separately. Nor am I sure that such a study would be useful since one feature of technical change is the changing composition of the stock of capital; there is now, for instance, more specialised equipment than in former times. Moreover a large proportion of assets are tailor-made or consist of built-in fixtures, such as pipes carrying steam or hot water, and it is impossible to measure these in common physical units. Hence our measurement is again essentially in terms of economic units and not in physical ones. We have taken whole industries and we have taken all assets (only separating buildings from plant and excluding vehicles).

The study we made of the length of life of assets in British manufacturing is in essential respects similar to demographic studies
concerned with human life. We make use of concepts similar to the number of births, the number of deaths, age at death and length of life. Chart 2 shows survival curves for plant (excluding buildings) in the engineering industries and is similar to survival curves which would be prepared by life insurance companies for human populations. The difficulty is that capital assets are more heterogeneous than human beings and also that length of life is only to a minor extent determined by physical factors. Length of life is mainly dependent on business decisions; most assets are discarded not because they wear out but because they become obsolete and are superseded by other assets. Death is not natural but the result of homicide committed in order to establish a new favourite.

The major statistical problem in a study of this type is that one has to obtain records relating to the past and few business firms have data for a sufficiently long period. Business records have been improving over the past decade but they are still not universally good and of course the defects of the past can no longer be remedied. Even if better systems are introduced we will have to wait 20 or 40 years before enough data accumulate.

In the ideal case when an asset is acquired a card is made out recording, among other things, the date and cost of acquisition. This card is kept on the register so long as the asset is in use. When the asset is taken out of use the card is removed and a final entry made of the sale value of the asset. Rough approximations to this ideal case were found in a number of firms and a sample study made of about 60. One cannot pretend that these firms form a representative sample but the results are probably acceptable within limits and appear relatively reliable for the engineering industries.

In the capital intensive industries, such as steel or paper, records are difficult to obtain because assets last a long time and because in the course of their life they are substantially modified, so that even a precise statement of the problem becomes difficult. In the paper industry, for instance, there have been no fundamental technological changes for at least 60 years, but machines have become bigger and faster. In old factories machines were driven by steam but in the course of time electric motors were used instead. The original rollers had bronze bearings which were replaced by ball bearings. In almost each year there was some improvement to make the old machines faster and more accurate. With faster machines the factories had sometimes to be made longer and this was also done. The only thing it was impossible to do was to make the rollers longer. In fact newsprint is produced on the latest wide
and fast machines while the machines with narrower rollers, previously producing newsprint, have been converted to other types of paper.

Chart 2 shows two curves based on two different statistical methods. First we asked companies to state the proportion of investment made in particular years which still survives; e.g. of £ 100 invested in 1909 £ 60 may still be on the books so that the survival rate at age fifty is 60%. The calculation is entirely in terms of money: how much was paid for assets 50 years ago and how much is still there in terms of original cost. Types of asset are not distinguished. We do not have to bother about the problem of inflation because we are comparing quantities in identical sets of prices. Fifty year old assets are measured in prices of 50 years ago, and 40 year old assets in prices of 40 years ago. This gave us line A averaging results for about 40 firms.

We also asked another question to find out what was scrapped last year or in the last 2 or 3 years. We asked for the original cost of the assets scrapped and also for total investment in the year of acquisition. The scrapping rates obtained are similar to mortality rates according to age in a study of human life. Again we did not have to bother about changing price levels. By cumulating scrapping rates we obtained another survival curve marked B.

For some firms we obtained both sets of information but others, for technical reasons, could give only one. The difference between the two curves is thus partly due to differences in coverage and partly to differences in method. Theoretically the two curves ought to be identical if one assumes that mortality rates do not change over time.

The first calculation is based on average mortality rates ruling in the past and the second on the most recent mortality rates. In fact curve B indicates a longer length of life than curve A and this is consistent with the hypothesis that in recent years (1955-1957) the rate of scrapping was below normal. In boom periods scrapping is postponed. The data offer no evidence that the average length of life of industrial machinery is shortening.

Chart 2 suggests that engineering plant is discarded fairly evenly beginning almost with the installation of new plant. About one-half of the total survives the age of 35 but beyond this age there is uncertainty because of lack of information.

The data collected by us support the assumption that the actual average life of industrial capital is longer than implied in depreciation allowances. This conclusion is confirmed by opinion obtained from a number of firms. There are of courses classes of assets
where the difference is not large. It is more important that for
depreciation purposes assets are supposed to disappear at certain
specific intervals, such as 20 or 30 years, whereas in fact the
discarding of assets in a given industry appears to be fairly
continuous.

One practical application of the two studies described is that
they enable us to make an assessment of the replacement needs of
British manufacturing industry. The combination of a realistic
valuation of assets and a realistic assessment of mortality rates
indicates that in the last 3 or 4 years replacement requirements
amounted to £250-300 million annually. This is equivalent to one-
third of gross investment in manufacturing, leaving two-thirds for
net additions to the stock of capital. A realistic depreciation estimate
would amount to about one-half of gross investment; it is well-
known that in an expanding economy depreciation exceeds replace-
ment.

On the basis of these calculations the rate of growth in the stock
of fixed capital in British manufacturing was 3 to 4 % in recent
years on a gross basis (and even more on a net basis) which is a
respectable rate for a so-called mature economy.