

Capital Consumption : National vs. Business Accounting Points of View

J. M. Hashim

Ministry of Planning, Bagdad, Iraq

Introduction

Two groups of people are generally responsible for the calculation of capital consumption charges, each serving a specific purpose. The first are business accountants who generally define capital consumption as “the actual accounting provisions charged against income by public and private enterprises for depreciation and extraordinary obsolescence of fixed capital, plus the insurance claims for accidental damage”.¹ Within this general concept a number of alternative techniques are developed, each leading to a different apportionment of total charges over time, and to different values of such totals as well. Once the business accountants have approved a specific method, the accounts are prepared and published accordingly. This faces other parties with the problem of discovering whether the techniques adopted do fit their purposes, and consequently what types of amendments would be necessary. An important party is the second of the two groups mentioned above, namely national accountants who approach the problem from an economic point of view. To them, capital consumption means the decrease in value, at current prices, of durable physical assets. Alternatively, it may be defined as the present cost of replacing the current loss in economic worth from wear and tear and obsolescence of physical assets.

Generally speaking, the former group of accountants is interested in regaining the money which has been sunk in physical assets, while the latter emphasizes the maintenance of resources at a level equivalent to the sum total of all previous decisions on investment. Unfortunately, the concept of the national accountants has not been developed satisfactorily enough to provide a unique definition for measuring capital consumption. Two reasons have been responsible for this; the first is the lack of information in capital accounts prepared by business accountants, and the second is due to other problematic factors such as technological change, changes in demand, etc.

The purpose of this paper is to investigate some of the practical problems involved in measuring capital consumption, with an attempt to furnish a basis for closing the many gaps, and indicate solutions that would meet the needs of national accountants. It is hoped that this would help economists in general and planners in particular in agreeing on a practical solution to a problem of crucial importance in development planning of developing economics. The problems will be classified under the following general headings, derived from the definitions quoted above: Depreciation – Obsolescence – Insurance Claim Payments – Determination of the Life of Assets.

In Part I we shall deal with depreciation, its various aspects, and the effects of changing prices on its measurement. The other three items are considered in Part II.

¹ United Nations, Statistical Office. Concepts and Definitions of Capital Formation. *Studies in Methods*; Series F. No. 3, p. 15.

Part I. Depreciation

Definition. Leaving price changes aside, depreciation means the amount by which the value of an asset falls over time. In other words, depreciation measures the extent to which the value of the asset has deteriorated although it is being kept in a good state of repair. Deterioration of the value of an asset, even though it is well maintained, may be caused by several factors, among which we may recognize the following:

1. In the process of using the asset some portions may be consumed; e.g. rubber parts worn away.
2. The cost of operating the asset may increase, either because it needs more input of labour and material per unit of output, or because it breaks down more frequently with the result that maintenance costs go up. This reduces the expected net output and hence the value of the asset.
3. The physical yield of the asset may decline. For example, the physical output of the valves in most electrical appliances declines with use.
4. The invention of a new asset – a machine for instance – causes a decline in the value of the old one, either because the new one is cheaper to operate, or because it is less expensive to produce and install.
5. Finally, the asset may lose value simply because new products come on the market which buyers prefer to that for which the given asset has been designed.

Practical aspects of depreciation. The problem of the depreciation of fixed assets and the measurement thereof faces the business accountant before anyone else. Ideally, the solution should conform with that suitable for the purposes of the national accountant interested in the calculation of income at the level of the nation rather than that of the individual concern. However, it is practical rather than conceptual soundness that characterizes the business accounting approach. There is need to introduce some adjustments in the calculations thus made, before they can be employed in national income accounting. In what follows there will be an attempt to survey the accounting treatment of depreciation, and to indicate the necessary departures therefrom, in estimating capital consumption for national income accounting purposes.

It is in moving from the financial and commercial sectors to those of industry that we discern the growing importance of depreciation, and the significant role it plays in the internal economy of those sectors. Whilst the problem of capital consumption has been with us ever since capital goods were produced in one form or another, we can safely say that the problem arose with the “Industrial Revolution”. It is natural, therefore, that most of the thinking on this problem has been done by British and American accountants and economists, and it may be observed that they share similar views on it. The elements of depreciation in general consist of the following:

- (i) The apportionment of the cash price over the useful life of the asset.
- (ii) The adjustments necessitated by price changes.
- (iii) The valuation of fixed assets for balance sheet purposes as distinct from the ascertainment of income.
- (iv) Retirement due to accidental damage or obsolescence.

The basis of the charge for depreciation in the accounts of business concerns is the original cost of the asset. All the other matters, some of which remain very controversial are treated as an adjustment of this basic charge. The first major exception to this general consensus arises in the case of the depletion of natural resources, particularly in mining. The argument

here has been that the essential purpose of depreciation being the maintenance of the capital sunk in the concern, is unnecessary in the case of mining, etc., because the original mandate does not cover the employment of the depreciation fund in ways other than the original investment. It can readily be seen that this approach, which has also been shared by income tax legislation, is close to viewing depreciation from a national income accounting viewpoint.

Akin to the depletion of natural resources is that of long term social investment, particularly in the case of public utilities such as railways. One aspect of the argument in this context was the economic case for charging the public using the utility a price high enough to allow for the depreciation of the fixed assets, as opposed to merely raising an additional percentage to service the capital sunk therein. Again we find a corollary to this approach in the attitude of the Inland Revenue (U.K.). In the 1920s a commission found that an investment which had a useful life of over a generation, should not be entitled to a capital allowance in the computation of taxable income.¹

With regard to national income accounting, the criterion for the correct method of treating the depreciation of long term social investment, depends on the definition of national income. Theoretically we may choose any definition to our daily problems that should determine our choice, moreover, it has to be technically feasible. However, any departure from, or modification of, the basic premises of income measurement should be clearly stated; i.e. the difference between our working conventions and economic concepts should not be overlooked. It is, therefore, suggested in this investigation that a long term social investment once made, becomes an integral part of the natural resources of the country, and that apart from the cost of repairs and maintenance, which is a current expenditure, no capital consumption of these assets should be included in the computation of net capital formation. The U.N., in this respect, suggest two alternatives: "The *first* is to treat repair and maintenance expenditure on long-term investment as current expenditures and hence omit capital consumption allowances for this item. The *second* is to include as capital formation all expenditures for maintenance and repair, and to include a provision for their loss of economic value in estimates of capital consumption, on the basis of an estimate of the expenditure required to maintain their original condition." See U.N.S.O. *Studies in Methods*, Series F., No. 3 (New York, 1953), Par. 61, p. 14.] With regard to marginal cases, which arise as a consequence of such broad conventions, these should be treated on their individual merit in the light of the above considerations.

But for these two departures, the principles of apportionment of the cash price over the useful life of the asset, can be said to have become universally accepted.

Distribution over time. With regard to the methods of apportionment of the cash price – less the scrap value – over the useful life of the asset, practice varies and the official pronouncements of the accounting bodies as to the best practice can only be seen as the guiding light to the various methods in practice employed. Some doctrines have been emphasized more than others in these official recommendations and pride of place has been given to consistency in the application of any method.

The two most popular methods are the *fixed instalment* (i.e. straight-line method) and the *reducing balance system*. [For the derivation of formulae for alternative methods see Appendix.] The former is particularly favoured by the Institute of Chartered Accountants in England and Wales. Under the latter system a higher charge is made in the earlier years than in the later.² Some argue that this is necessary in view of the higher repair and maintenance bills in later years. Others prefer this method because of inherent results of deferring profit until

¹ Report of the Royal Commission on the Income Tax. Cmd. 615, 120.

² Cf. C. H. Feinstein, *Domestic Capital Formation in the United Kingdom 1920-1938*, Cambridge University Press, 1965, p. 3.

later years. The English Institute, however, in favouring the fixed instalment method attempts to take an impartial attitude towards the profits of earlier or later years.

Neither of these two methods takes the cost of finance into consideration, which becomes necessary if we regard the cash price of the asset as the discounted value of future receipts or services provided by the asset to production. A method that takes this into consideration is called the *annuity method*. Under this method the latter years are charged at a higher rate of depreciation than the earlier years. In other words, the service provided by the asset in the first year is paid for in that year whilst that provided in the last year, say the tenth, is paid for ten years before and is therefore more costly.

It is one of the arguments for employing a falling charge over the life of the asset to say that, as the life of the asset expires, and its unrecovered cost is diminishing, the financial cost of holding the asset also diminishes. However, this argument is only relevant if we are measuring the cost to the economy (or the firm) of making an investment, i.e. deferring

Table I. *Depreciation allowances, alternative methods (A = 1000)*

Year (<i>t</i>)	Fixed instalment	Reducing balance	Annuity method
1	100	300.0	79.5
2	100	210.0	83.5
3	100	147.0	87.7
4	100	102.9	92.0
5	100	72.0	96.6
6	100	50.4	101.5
7	100	35.3	106.5
8	100	24.7	111.9
9	100	17.3	117.5
<i>n</i> = 10	100	12.1	123.3

consumption by adding a percentage to cost. The annuity system, on the other hand, is an attempt to redistribute the fixed instalments, i.e. the cost over the period of useful life of the asset without adding any percentage.

This method is suitable for assets with a long life, particularly if they expire, like leases, at a definite point of time. The method is not suitable for assets of a miscellaneous character such as plant, machinery, etc., because additions and renewals obviously necessitate fresh calculations and adjustment of the annual charge.¹

Table I and Figure 1 are illustrations of the effect of employing each of the three methods of cost apportionment described above. The computations are based on the assumptions that:

A = Original cost of asset = ID. 1000

n = Useful life of asset = 10 years

r = Discount rate = 5 per cent

The computations are based on formulae given in the Appendix.

$\frac{1}{m}$ = Annual rate of depreciation, Reducing Balance System = 0.3.

It should be noted that in the reducing balance system total depreciation allowances at the end of the tenth year add up to ID. 971.7 and not 1000. The difference is usually written off as scrap value.

¹ S. W. Rowland, *Principles of Accounting*, The Donnington Press, 1961, p. 279.

The role of interest rate. If capital consumption is appropriately measured it becomes obvious that over the whole life-cycle of capital goods, capital consumption and capital formation in constant prices must be zero. Our problem, therefore, is simply one of allocating the full life of capital goods over time. One may question whether the phenomenon of interest – which was practically avoided in our example – and discounting has any effect upon this allocation.

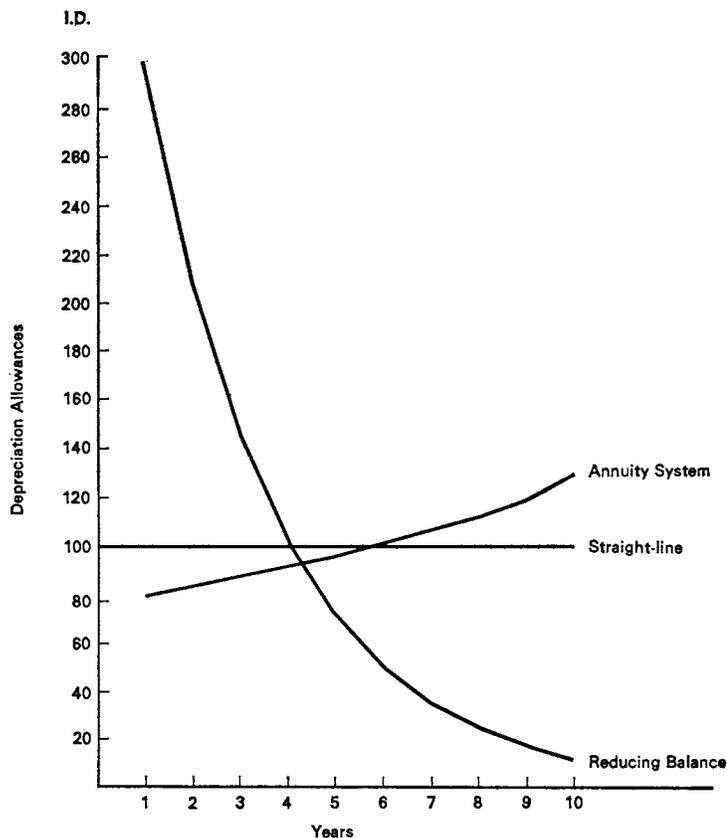


Figure 1.

It is sometimes said that an interest rate – as distinct from changes therein – should influence the time allocation of capital consumption. S. Fabricant [*Capital Consumption and Adjustment*; N.B.E.R., 1938], for instance, says that:

“the fluctuations in depreciation charges on a given capital good . . . should be superimposed on a rising secular trend, to take account of the element of interest. That is, if output is constant, depreciation charges should rise, the rate of rise depending on the rate of discount implicit in the original capital value. . . . Here also the choice of the method of allocation must rest on what is believed to be the expectations of investors”.

J. R. Hicks [*Value and Capital*, 2nd Ed., London, Oxford University Press, 1948, pp. 128–179], on the other hand, emphasizes that since capital formation and national income statistics are *ex-post* measures of what has happened in the past, the introduction of interest rates in the calculation makes these measures needlessly dependent upon *ex-ante* expectations as of some past date. These are wholly irrelevant to a measure of the economy’s performance. There is no reason, it is said, why the interest rate anticipated by the purchaser of a capital

good in year t should determine the allocation of capital consumption charges in year $t+1$, $t+2$ and so on.

There appears to be a general agreement that changes in the market value of existing capital goods, due to changes in the rate of interest, play no role in determining either the total of capital consumption charges or their time allocation. They are in essence capital gains or losses, which are conventionally excluded in national income accounting, and from the viewpoint of business accounts this falls under capital revaluation and not in the estimation of capital formation, nor in the apportionment of the cash price.

Comparison of alternative methods. The example given before shows that for the computation of depreciation charges of an asset the information required is:

- (a) Cash price.
- (b) Scrap value; which was nil except in the case of reducing balance where it amounted to ID. 28·3.
- (c) The useful life of the asset.
- (d) The rate of production, or the intensity with which the asset is used—assumed in the above to be constant.
- (e) The rate of interest. This is the rate at which capital may be borrowed for a specific asset with a particular length of service and a particular degree of risk.¹
- (f) The change in the rate of interest, which was assumed nil in our example.¹

The effect of employing any of the methods discussed before is clear from the graph. It can be shown, for instance, that the longer the life of the asset, the greater the differences between the annuity method on the one hand and the other methods on the other, and consequently it becomes more necessary to employ the sounder method. Again, the longer the life of the asset, the smaller is the difference between the reducing balance and fixed instalment methods. Given, therefore, that the annuity method is the soundest theoretically, we can see how in long-term social investment the depreciation in the earlier years is almost negligible, which fortifies the decision to exclude it from the computation of capital consumption.

Price changes and depreciation charges. There has been much controversy with regard to the need to take into consideration, in measuring the income of business enterprises, changes in the price levels, whether specific or general. Whilst changing prices affect the accounts of business concerns in more than one way, we are here concerned with the effect of price changes in the charge for depreciation of fixed assets. In calculating depreciation charges, current accounting practice takes no account of year-to-year changes in the price originally paid for fixed assets, because what is important to the business concern is usually to maintain intact the original money value of the investment; this is also most often sanctioned by income tax authorities.

Suppose there is no change in the price of a particular machine and the general price level is unchanged, but a new model of the machine is introduced which yields more output and at the same time costs the same as the old one. If the old machine is replaced by the new one the proprietor's capital is unchanged in general purchasing power but the real productive capacity of his firm is increased. Consequently, his real capital in terms of real output is higher. However, when prices change, the question of whether depreciation charges should be adjusted becomes important, and if these changes are to be adjusted, what method should be employed.

Up till now the discussion has remained in the conceptual stage since the various authorities

¹ In the example given in the text, the rate of interest was assumed to be 5 per cent. For further implications of this rate see preceding section.

have not yet come to a sufficiently wide ground of agreement on the methods to be employed. The basic difference between various thinkers as to the adjustment of depreciation charges due to price changes, is on what constitutes a price change. Some argue that there is no price change to take into account unless the general level of prices changes. Others consider the relevant price changes to be those of the specific asset. The arguments have centred around two doctrines: (a) the preservation of the capital of the enterprise and, (b) the provision of finance for replacement by means of an adjusted charge. With regard to the second doctrine, while some accountants have argued that there is no relationship between provision for finance and the charge for depreciation, the whole idea is of a utilitarian nature, and is of no relevance to national income accounting, since here we are not concerned with the availability of finance to a particular concern.

It is the former doctrine of maintaining capital intact that has some relevance to national income accounting. When prices change, the effect on capital consumption is twofold and in opposite directions. One effect is of a current nature and enters into our national income accounting, the other is of a capital nature and is conventionally ruled out from national income accounting as capital gain or loss.

To illustrate, suppose prices rise by 50 per cent, and the two effects are as follows. We have a 50 per cent increase in the value of the asset which we were holding before the price change. This is a capital gain. In other words the business (or the owners) is better off by 50 per cent on its assets. The second effect of a current nature arises from the first, and it is in the nature of a current loss or charge. Since there has been no change in the productivity or life of the asset, we have to apportion a further 50 per cent of the value of the asset over its remaining life. When the specific price of the asset moves in the same direction and extent as the general price level, the problem is as simple as in the case where all prices are unchanged. Here is no capital gain but an adjustment of assets and liabilities equally. The depreciation charge will similarly be higher. This is a case of a loss in the value of money, and there is no difference between the specific or general price index.

It is when these latter two indices are different that we have to choose which to adopt. It is suggested¹ that accounting from an entity point of view and on a going concern basis requires the adoption of the specific index. But in accounting for national income we must segregate the two movements in prices. That is to say, we must first of all eliminate the overall changes in prices by deflating through a general index. Then we must account for variations in the prices of specific assets by adjusting the depreciation charge of each asset according to its new value. [This argument is also used, and substantiated, by Colin Clark in *The Conditions of Economic Progress*, Macmillan, London, 1957, pp. 565-615.]

The argument in support of this method is as follows: General price movements have no effect on accounting for national income since this only indicates a variation in the value or purchasing power of money. Therefore, the first step is to eliminate the effect of any such general price movement. With regard to movements in the prices of specific assets (having eliminated the effect of general price changes) there is a material effect on national income. For example, if it becomes cheaper to produce further units of a specific asset, the economy incurs a capital loss, equivalent to the fall in the cost of producing such an asset, and the annual depreciation of the existing asset will consequently be lower.

Other aspects of depreciation

1. *Subjective depreciation.* Depreciation under this heading is defined as the amount necessary to permit the maintenance of subjective value, i.e. to permit the maintenance of a

¹ Gynther, R. S., Accounting for price level changes; an article published in: *Accountancy*; The Journal of the Institute of Chartered Accountants in England and Wales; Vol. LXXIII, No. 826, July 1962, pp. 560-564.

constant stream of income, should the owner of capital so desire. Thus subjective depreciation considers as income the interest on the S.V. (subjective value) of the capital good: S.V. being the discounted sum of all quasi-rents plus scrap value. [“When an entrepreneur contemplates the purchase of a machine he must compare the expected value of the services the machine will render to the costs he must incur in acquiring the machine. The value of the machine in any period is a ‘Quasi-rent’ and is determined by deducting from the proceeds he realizes from selling the machine’s output, all cost of production *except* depreciation on the machine and any interest costs related to the acquisition of the machine. These quasi-rents attributable to the machine will in fact cover the cost of the machine in order to finance that cost.” E. O. Edwards, *Depreciation and the Maintenance of Real Capital*, p. 48.] In other words, S.V. is the present value of the stream of quasi-rents expected over the lifetime of the capital good. If each quasi-rent is received at the end of each period, the S.V. of, say, a machine at the beginning of a period ($S.V._{(0)}$) is simply the subjective value at the end of the period ($S.V._{(1)}$) plus consumption, (C_1), both discounted one period. Denoting quasi-rent by Q , investment by I , consumption by C and depreciation by D , it can be shown (see Appendix) that:

$$Q_1 = C_1 + I_1 + D_1,$$

which means that each quasi-rent, Q_1 can be divided into:

- (a) Consumption C_1 and gross investment $I_1 + D_1$, or
- (b) Income $C_1 + I_1$ and depreciation D_1 .

2. *Market depreciation.* Under this heading, depreciation is considered to equal the decrease in market value of the asset; the rest is income. It is said that this method of depreciation permits the firm to maintain the market value of its assets as opposed to their subjective value. Assuming that prices are constant and no technological change occurs during the period, market value can be defined as the “constellation of market values, one for the new machine, one for a machine one period old, another for a machine two periods old, etc. The prices of machines of various ages are still constant over time but as each period passes a new market value is assigned to the ageing machine” [E. O. Edwards, *Depreciation and the Maintenance of Real Capital*, p. 59].

The application of this method of depreciation in practice needs the following conditions:

- (i) Second-hand markets for all types of assets of all ages.
- (ii) The markets should be perfect in the sense that anyone has equal access to both the buying and selling sides.
- (iii) Either there are no transport or installation charges, or these charges are so negligible that they leave no effect on the market value of the asset.

3. *Internal-rate depreciation.* This theoretical aspect of depreciation is based on the idea that an enterprise should earn an income in each period at an internal rate of returns applied to all investment in the assets. The internal rate is selected in such a way that by the end of the assets’ life, total depreciation plus the scrap value should equal the original cost of the assets. However, under this method, as well as under the subjective depreciation method, the income is given and the depreciation is a residual.

Comparing the three methods of depreciation discussed above we may find that subjective and internal-rate depreciation are of an arbitrary character depending as they do on expectations. One common feature of the three methods is that they all try to divide – although in different ways – the quasi-rent into income and depreciation. From a practical point of view, this division of quasi-rent is not usually regarded as a criterion for choosing a depreciation method. Accountants as well as other interested people often use other methods of depreciation such as the straight-line, declining balance, and the annuity system which have been discussed above.

Part II

Obsolescence. Obsolescence, broadly, means the decline in the value of capital goods associated either with a change in the structure of taste or with technical improvements that make newly produced capital goods more efficient than older capital goods used for exactly the same purpose. In other words, obsolescence is the loss in value which is due to the competition of new inventions. Both sources of obsolescence are likely to happen, and to be of significance when they do, in an advanced and progressive economy. The interrelation between technological and social changes causes shifts in the structure of tastes and in the efficiency of capital goods. The former type of shifts usually apply to capital goods used by consumers, while the latter apply to capital goods used by business and government bodies. Methods of calculating allowances for obsolescence and the allocation of these allowances over time gave rise to controversial issues in the field of national income in general and in the estimation of net fixed capital formation in particular. Among the opinions and suggestions in this respect three may be distinguished:

1. The first, and indeed the prevailing method in business practice, is to charge obsolescence against output by allowances spread over the economic life of existing assets along with those of physical depreciation. The justification of this method lies in the argument that there is a direct functional connection between the degree of obsolescence and the rate of utilization of the capital goods. Thus, even if old capital goods can produce the same amount of units at the same level of costs as new machines, rational calculation will not permit them to do so if the new capital goods are more efficient than the existing ones. From the economic point of view, non-use of existing capital goods is equivalent to its physical depreciation, i.e. less effective use because of physical wear and tear. This leads to the conclusion that obsolescence is gradual, reflecting the gradually cumulative effects of technical advancement which means that a systematic deduction is more appropriate than those suggested below.

2. The second method is to disregard the obsolescence accruing on existing capital goods and to charge it off *in toto* against gross capital formation (rather than adding it to capital consumption) when the assets are being retired. Those who support this method say that if obsolescence is deducted from the existing assets, capital stock will shrink and hence output per unit of net capital will rise not because there was an increase in productivity but only because an improved capital item, such as a machine, has been invented [E. F. Denison, *Theoretical aspect of quality change, capital consumption, and net capital formation, N.B.E.R.*, Vol. 19, pp. 215–284]. Thus, this method has the advantage of avoiding the hazardous forecast of future changes in demand, technological knowledge, and relative costs required in methods which allow for future obsolescence of existing assets. However, it seems to us that these advantages are illusory since determination of the time after which the capital good is retired is influenced by two factors: *Physical deterioration* and *obsolescence*. Moreover, net capital formation statistics should reflect current economic realities as fully as possible even if these statistics do not properly fit the general conceptual framework of a system. From a capital formation viewpoint the current ability of capital goods to contribute to production is reduced by physical wear and tear which is nothing more than a rough attempt to allow currently for a gradually accruing relative change in the ability of existing capital goods to contribute to production when the ability of newly installed facilities is used as the standard of measurement. Then, if we take depreciation allowances into consideration it becomes a natural supplemental step to try to allow also for that part of the productivity differential which is due to the superiority of the new capital goods rather than to their lower age.

3. The third method of dealing with obsolescence is to deduct only wear and tear allowances on existing capital goods, and to remove the terminal net book value on assets discarded as obsolete by a capital adjustment rather than by a deduction from income. Doctrinaires who argue in favour of this procedure say that “just as there is logic in saying that improved

design of capital goods is not more capital but an increase in its efficiency, so also it is perfectly reasonable to say that the efficiency of capital varies with its age, and that the deductions from the quantity of capital to make the productivity of existing capital a constant over its life are not consistent with the desired concept" [*N.B.E.R.*, Vol. 25, p. 395].

Insurance claim payments. The decision concerning the inclusion of insurance claim payments as part of capital consumption to account for accidental damage to fixed assets should take into consideration the treatment of "insurance" in the income and capital accounts. In fact, insurance premium charged to current accounts embrace three elements:

1. Factor Costs.
2. Additions to Reserves.
3. Claim Payments.

But in dealing with accidental damage to capital assets two points should be noticed:

1. Only claim payments for the destruction of real assets are included in capital consumption as measuring the loss from accidental damage. Other types of claim payments are regarded as transfers.
2. Claim payments for the accidental damage to *stock* are not included in capital consumption on the grounds that net change in stocks is adjusted for these losses before inclusion in capital formation.

The accidental damage to fixed capital may be measured by an alternative method. That is by taking the difference between premiums received by insurance companies and their operating expenses including, in the case of stock companies, dividends to stockholders. The result should equal the sum of claims paid plus net addition (if any) to resources made during the accounting period. However, some enterprises – especially those with widely scattered properties – do not insure their buildings and equipment but instead maintain some sort of reserves by periodic charges to income, against which they charge the losses caused by accidental damage to their fixed assets. The addition to such reserves is regarded as profit, while the loss charged against these reserves is then deducted from the profits in the period it occurs.

Determination of the life of assets. To end our discussion on capital consumption one important point should be given some consideration. That is how the life span of an asset is determined. The lifetime of a given durable good is usually of two types:

1. Technical lifetime.
2. Economic lifetime.

The first type ends at the moment when repair is physically impossible, while the second type – which is usually shorter than its maximum life – terminates at the point where repair costs necessary to enable the durable good to produce at least one additional unit of output exceeds replacement cost. [Under some circumstances the economic and technical life of a durable good may coincide. For further details see: E. O. Edwards, *Depreciation and the maintenance of real capital*, in *Depreciation and Replacement Policy*, editor J. L. Meij, North Holland Publishing Company, 1961.]

The way in which the asset is used has some effects on the determination of its life span since the maximum life of a durable good cannot always be defined in calendar time independent of the way in which it is used. For some durable goods, such as telephone lines, the maximum lifetime is independent of the time pattern of use; while for others, such as electronic and electrical appliances, the maximum lifetime is a function of the pattern of use. In this case the best we can do is to treat the pattern of use as an integral part of the definition of the good; a good having several possible patterns of use is in fact several goods. However, apart from the difficulties of measuring depreciation or replacement requirement which have

been investigated above, the assumption about the length of life of a particular asset over which its value is to be spread, in one way or another, introduces certain errors in the calculation. If, for example, the straight-line depreciation method is used, the assumption about the service life of an asset introduces one source of errors which have a serious effect on the figure of *changes in gross investment*, and a less serious effect on the figures of changes in net investment. For instance, if a particular class of asset is assumed to have a service life of 25 years, whereas in fact its lifetime is 15 years; *then the increase in gross investment* in 1962 will be as follows:

- (i) *Assuming 25 years' service life.* Value of new assets installed in 1962, less gross value (at replacement costs) of assets installed in 1937.
- (ii) *The 15 years' correct service life.* Value of new assets installed in 1962, less gross value (at replacement costs) of assets installed in 1947.

On the other hand, *the increase in net investment* in 1962 is:

- (i) *On the assumption of 26 years' service life.* Value of new assets installed in 1962, less $\frac{1}{25}$ of gross value (at replacement cost) of all assets installed in the 25-year period 1938–1962 inclusive.
- (ii) *On the correct service life of 15 years.* Value of new assets installed in 1962, less $\frac{1}{15}$ of gross value of all assets installed in the 15-year period 1948–1962 inclusive.

It is worth mentioning that although the year-to-year changes in the figures of net investment are less affected by the errors due to the assumption of length of life than are the year-to-year changes in the figures of gross investment, the *general level* of both series is affected to the same extent. In the example above, if we assume that the level of investment has remained constant over the period 1938–1962, the figures of gross and net investment at the end of 1962 would each represent $\frac{2}{3}$ of the true figures. It has been found¹ that if investment in each year is of the form

$$I_t = \alpha + \beta t + \epsilon t$$

where

α and β = constants

t = denotes the year

ϵt = a random element with mean zero and standard derivation σ ,

an error of λ years in the assumed length of life introduces the following two types of error:

1. Error in the estimate of the increase during any year in gross value of capital = $\beta\lambda + \xi$.
2. Error in the estimate of the increase during the year in net value of capital = $\frac{1}{2}\beta\lambda + \eta$

where

ξ and η have distributions with zero means and variances $2\sigma^2$ and $\lambda\sigma^2/L(L+\lambda)$ and L is the true length of life.

Appendix

1. Alternative Methods of Calculating Depreciation Allowances

Let A = Original cost of asset.

B_t = Value of asset at the beginning of year t .

C_t = Cumulation of depreciation allowances up to end of year t .

D_t = Depreciation allowances in year t .

n = Useful lifetime of asset, in years.

r = Discount rate.

¹ Redfern, P., Net investment in fixed assets in United Kingdom, 1938–1953, *Journal of the Royal Statistical Society*, A, 118, Part 2, 1955.

The following relations hold by definition:

$$C_t = \sum_{j=1}^t D_j, \quad B_t = A - C_{t-1} \quad (t = 1, \dots, n)$$

Also

$$B_1 = A, \quad B_{n+1} = A - C_n = \text{scrap value.}$$

A. Fixed instalment method

$$D_t = D = \frac{1}{n} A \quad (t = 1, \dots, n) \quad (1)$$

Hence,

$$C_n = \sum_{t=1}^n D_t = n \cdot D = A$$

and

$$C_{n+1} = A - A = 0$$

while

$$B_t = A - t \cdot D = (n-t) D. \quad (2)$$

B. Reducing balance system

The rate of depreciation in any year is $1/m$ of the value of asset at the beginning of the year:

$$D_t = \frac{1}{m} B_t \quad (3)$$

$$B_t = B_{t-1} - D_{t-1} = \left(1 - \frac{1}{m}\right) B_{t-1}.$$

Given that $B_1 = A$, the solution of this first-order difference equation of the first degree is:

$$B_t = \left(\frac{m-1}{m}\right)^{t-1} B_1 = A \left(\frac{m-1}{m}\right)^{t-1}. \quad (4)$$

Hence

$$D_t = A (m-1)^{t-1} / m^t. \quad (5)$$

C. The annuity method

Let a be a fixed annuity put aside at the end of each of the n years. If the discount rate is r , the annuity needed to build a sum equivalent at the end of year n to the amount $A(1+r)^n$ obtained by investing an amount A for n years at the compound rate r , is:

$$a = A \cdot r \left[1 - \left(\frac{1}{1+r}\right)^n \right]. \quad (6)$$

If we withdraw at the end of each year the annuity a , the whole value of the asset and its interest earnings would be consumed by the end of year n . Hence we have to withdraw the annuity less interest earnings of the depreciated value of the asset during that year:

$$D_t = a - rB_t. \quad (7)$$

Thus:

$$B_t = A(1+r)^{t-1} - \frac{a}{r} [(1+r)^{t-1} - 1] \quad (8)$$

and

$$D_t = (a - rA)(1+r)^t. \quad (9)$$

Equation (8) shows that if a satisfies (6), then

$$B_{n+1} = 0.$$

2. Subjective Depreciation

Let $SV_{(0)}$ = Subjective value of a machine, say, at the beginning of the period.

$SV_{(1)}$ = Subjective value, end of period.

i = Rate of interest.

Y = Income.

C_1 = That amount of income which is consumed.

I_1 = That amount of income which is invested.

D_1 = Depreciation.

Q_1 = Quasi-rent.

Then, $SV_{(0)}$ is the value of $SV_{(1)}$ and C_1 discounted one period:

$$SV_{(0)} = \frac{SV_{(1)} + C_1}{1 + i}.$$

Income is the rate of return on $SV_{(0)}$:

$$Y = (i) SV_{(0)} = (SV_{(1)} - SV_{(0)} + C_1). \quad (10)$$

Hence,

$$I_1 = SV_{(1)} - SV_{(0)}. \quad (11)$$

Let $SV_{(T)}$ = The subjective value that would be obtained if the whole quasi-rent is consumed.

Then,

$$Q_1 = (i) SV_{(0)} + (SV_{(0)} - SV_{(T)}) \quad (12)$$

Where,

$$D_1 = SV_{(0)} - SV_{(T)} \quad (13)$$

It follows that:

$$Q_1 = C_1 + I_1 + D_1 \quad (14)$$

Résumé

Amortissement industriel: le point de vue des comptabilités nationales comparé à celui des comptabilités commerciales

En général, deux groupes de personnes sont responsables du calcul des amortissements industriels: les comptables commerciaux et les comptables nationaux.

Le premier groupe considère l'amortissement comme étant la dotation comptable effective retranchée du bénéfice par les entreprises publiques et privées, pour tenir compte de la dépréciation et de l'obsolescence des immobilisations, et également des charges financières pour l'assurance contre les dommages accidentels.

Pour le deuxième groupe, c'est-à-dire comptables nationaux, qui considèrent le problème d'un point de vue économique, l'amortissement représente la diminution de la valeur, en prix courants, des immobilisations matérielles. Autrement dit, il est le coût actuel de remplacement de la perte en richesse économique due à l'usure-obsolescence des actifs matériels.

Les différentes méthodes de détermination de l'amortissement selon le concept adopté par les comptables commerciaux sont discutées. Chaque méthode conduit à une ventilation différente des charges totales dans le temps, ainsi qu'à des valeurs différentes de ces charges.

En ce qui concerne le concept adopté par les comptables nationaux, on constate malheureusement que celui-ci n'est pas suffisamment élaboré pour permettre une formulation unique, du calcul de l'amortissement.

Le but de cette étude est de discuter quelques problèmes pratiques inhérents à la détermination de l'amortissement, en vue de combler les diverses lacunes qui existent, et d'indiquer des solutions qui soient conformes aux besoins des comptables nationaux.

L'étude est divisée en deux parties: la première traite de la dépréciation, de ses différents aspects, et des effets des changements de prix sur son calcul.

La deuxième partie discute les problèmes d'obsolescence, de versement des charges d'assurance, et des effets de la longueur de vie des actifs sur la détermination de l'investissement brut et net.