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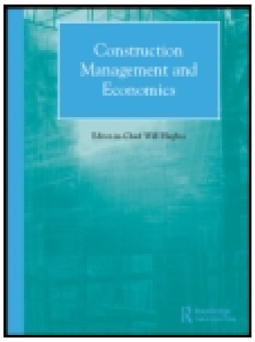


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# The measurement of productivity in the construction industry

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*Productivity in the use of resource inputs is of critical importance to the construction industry. This paper is intended to discuss the relative merits of the most commonly used measures of productivity for the purpose of assessing the productive and allocative efficiency of construction in the 1980s.*

*The paper concludes that the total factor productivity method is the ideal against which the other approaches should be judged. Both average labour productivity and average capital productivity suffer from serious problems in assessing the efficiency of contracting operations. However, under certain circumstances, either can provide an adequate alternative measure.*

*Of the two main single-factor measures of productivity, capital productivity appears to be superior in most aspects to average labour productivity as a means of assessing the overall financial management of a construction firm. Notwithstanding the problems associated in contracting activities and also the difficulties inherent in obtaining suitable data, capital productivity is recommended for most circumstances when total-factor productivity measures cannot be applied.*

Keywords: Productivity, economic efficiency, resource allocation, production function

## Introduction

### *Background*

The importance of productivity growth to an individual enterprise, an industry, or an economy is something on which most economists would agree. For example, Bowen (1984) asserts that 'Productivity performance is perhaps the best single indicator of an economy's vitality'. The UK and subsequently the USA originally gained economic pre-eminence by producing more goods with less labour, and at lower cost than their main competitors. Similarly the strong economies in recent years – for example Japan and West Germany – have achieved this through rapid improvement in productivity.

Unfortunately, no such agreement exists when it comes to defining precisely what 'productivity' actually is and which of the numerous alternative approaches to productivity measurement is suitable for a given task.

Productivity is associated with efficient use of the various factors of production. Efficiency, in this context, has two somewhat distinct meanings (Lowe, 1986b): (a) productive efficiency and (b) allocative efficiency.

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(a) Productive efficiency is concerned with the quality and cost of inputs with the aim of minimizing the unit cost of production. There are three aspects to this: (i) Inter-enterprise comparisons: any productive unit which is operating in a market environment will need to maintain competitiveness against other firms. Thus unit costs must be kept as low as possible. (ii) International comparisons: any domestic industry must remain competitive with foreign opposition so as to ensure long-term survival. An example of this might be to compare the UK construction industry with that of Japan. (iii) Inter-industry comparisons: if the real cost of the products of one industry rise in comparison with others then either the proportion of gross domestic product absorbed by that industry will rise (Harvey, 1981), or the physical product, and hence the relative importance of that industry will decline (Lowe, 1986a). Thus, if the cost of new buildings is rising, it is to be expected that more firms and individuals will make do with old buildings.

In this context productivity has no meaning in absolute terms but is useful only as a basis for comparison. However it may also be used for comparison of a firm, a sector, or an industry over time.

(b) Allocative efficiency is concerned with the distribution of scarce resources to the various productive units within the economy. The aim here will generally be to approach as near as possible to Pareto optimality – that is the situation when it is impossible to make anyone better off without making someone else worse off by reallocating resources.

This aspect of productivity assumed a central role in economic thinking during the era of rapid economic growth in the developed economies during the 1950s and 1960s. At that time the key economic problem was that of increasing output given a situation of full employment of all resources – notably labour. Thus in order to maintain the momentum of economic growth it was necessary to increase the efficiency or the intensity of use of resources.

## *Objectives*

This paper is concerned with alternative definitions as to precisely what 'productivity' is, so as to attempt to clarify some of the muddled thinking which appears to equate productivity growth with increased competitiveness and reduction of unit costs regardless of the facts of the individual case. Having considered various alternative broad definitions of productivity, the paper will attempt to select the most appropriate definition for the conditions appertaining to the late 1980s for the construction industry: specifically the contracting and speculative sectors.

## *Measures of productivity*

Productivity is usually measured in terms of a ratio of some measure of output to some measure of resource inputs. Of the three traditional factors of production, land is usually assumed as a fixed resource and consequently is not considered for the purpose of productivity measurement. This stems from the separation of the role of developer from that of the contractor in the non-speculative sector of construction. Land remains the prerogative of the client or developer while labour and capital are the responsibility of the contractor.

This leaves us with labour and capital as the inputs against which productivity is normally assessed. Labour productivity, and to a lesser extent, capital productivity are widely used as measures of economic efficiency and have, at least, the advantage of simplicity. They do, as single-factor productivity measures, suffer from a weakness in that neither includes the total productive process and they do not adequately deal with the impact of technological change and factor substitution (Weber and Lippiatt, 1983). The total factor productivity approach arose in response to these problems and will be discussed along with the single-factor measures.

## Single-factor measures

### *Labour productivity*

Labour productivity is the most widely used yardstick of operational efficiency. This does not imply that labour is the best input element for productivity measurement 'but simply reflects the difficulty or impossibility of obtaining numerical values for the other determinants of productivity' (Rendall and Wolf, 1983). Thus many of the essays on productivity seem to assume that labour productivity is the only suitable measure, or else productivity is tacked on to a discussion of labour inputs. See, for example, Bowen (1984) and Metcalf and Richardson (1984). Of recent studies of productivity in the UK construction industry, Harvey (1981) employs labour productivity uncritically, while Hillebrandt (1984) uses it with some caveats.

One common measure of is average labour productivity – a ratio of output per employee.

$$\text{Average labour productivity} = Q/L \tag{1}$$

where $Q$ = output
$L$ = labour employed

There are some problems in formulating the output ($Q$), since to mean anything, it should be presented net of all inputs – in 'value added' format. Unfortunately many of the most accessible statistics are presented in gross format (Sugden, 1978).

In addition, the labour employed ($L$) has to be quantified and while to take it as the number of operatives has, at least, the advantages of simplicity and because it utilizes statistics which are fairly easily available, at least in global terms. It has, consequently, been widely used (O'Brien, 1976), and in some cases misused (Sugden, 1978). Numerous permutations on this theme have been formulated – output/operative hour, output/operative year, index of labour costs, etc.

In this context, average labour productivity is a measure of the labour intensity of the productive process and does not necessarily imply anything about the efficiency of use of resources. Labour productivity can thus be increased by substituting another factor – usually capital – for labour. This substitution may or may not result in a better use of resources and cheaper unit costs of production.

Thus, for example, if plant is substituted for site labour, this will improve labour productivity. Similarly using off-site fabricated components, which involves substituting off-site labour for on-site labour (or alternatively materials for labour), will also improve average labour productivity.

It is by no means ensured that either of the above will result in productive or allocative efficiency. Productive efficiency will follow if the factors being substituted – capital or materials – are cheaper than the factor being replaced, i.e. site labour. Allocative efficiency would follow if the factor being replaced could contribute more to the total welfare of the economy by being employed elsewhere.

A problem which applies particularly to contracting is that, given the extent to which subcontracting is employed by many construction firms, the number of directly employed operatives may be very small or even zero. This can produce average labour productivity figures which may tend towards infinity even if the output statistics are in value added form.

An alternative measure is that of marginal labour productivity.

$$\text{Marginal labour productivity} = \partial Q/\partial L \qquad (2)$$

Marginal productivity is more useful in managerial terms than average productivity in that it defines the increase in output that will stem from the application of an additional unit of labour.

### *Capital productivity*

Capital productivity is usually defined in terms of a percentage return on capital invested, either using a traditional method such as Average Rate of Return or a discounted cash flow method such as the Internal Rate of Return method (Hawkins and Pearce, 1971).

$$\text{Average capital productivity} = \Pi/K \qquad (3)$$

where $\Pi$ = profit
$K$ = capital invested

In order to calculate capital productivity an estimate will be required of the value of the fixed capital stock. Problems exist, since different methods of valuing capital assets exist and since all estimates will be, to some extent subjective, in that the managers of a company may have a different view from the shareholders, as may a potential asset stripper. In any event, such information is unlikely to be readily available (Rendall and Wolf, 1983). Capital productivity is thus less widely used than labour productivity.

Despite these practical difficulties, capital productivity is a far more useful criterion than labour productivity for judging the performance of a enterprise operating within a market economy. Most private firms will seek to ensure an adequate return on capital invested to their shareholders – thus a high return on capital invested is far more relevant than high output per operative.

A particular feature of the construction industry is that since much of the fixed capital – plant and equipment – is hired and because, being sited based, no factory accommodation is required, fixed capital costs are low and can be treated as a variable factor in the short run. This stands in stark contrast to the situation in manufacturing. Thus a feasible way of increasing short-term output might be to hold the labour inputs fixed and apply more capital. The fixed capital requirements for contracting will thus tend to be low and while working capital needs will generally be more significant (Hillebrandt, 1984), in certain circumstances this may be very low or even negative.

This leads to serious problems in utilizing capital productivity for a construction firm in that, due to the very low capital requirements for contracting, the return on capital invested may be very high indeed and may tend towards infinity. In practice, most contractors will invest their surplus profits in other areas such as plant hire or property development thus increasing the shareholders' capital invested in the company.

Even after allowing for the above, the ratio of capital employed to turnover by large construction companies (1980 = 37%) is lower than for firms in the manufacturing industry (44%) and is comparable to non-manufacturing firms (38%). This disguises the fact that for contracting firms the capital/output ratio is considerably lower at 23% (1980) while for speculative housebuilders it is considerably higher at 61% (Hillebrandt, 1984).

Thus it can be argued that for contracting companies the return on capital invested is more a measure of efficiency of the firm in non-contracting activities, for example, property speculation, while for the housebuilder it is a measure of marketing success – selling completed house quickly – and is also related to the value of landholdings maintained.

### *The production function*

In order to refine the definitions of marginal productivity some consideration of the production function is necessary. The most common formulation is provided by the Cobb–Douglas production function. Assuming perfect competition the model can be presented thus:

$$Q = AL^{\alpha}K^{\beta} \tag{4}$$

where $A$ = constant of efficiency
$\alpha$ = distributional parameter (labour)
$\beta$ = distributional parameter (capital)

The distributional parameters are defined thus:

$$\alpha = wL/Q \tag{5}$$

$$\beta = iK/Q \tag{6}$$

where $w$ = wage level
$i$ = return on capital invested

$$\partial Q/\partial L = \alpha A L^{\alpha-1}K^{\beta} \tag{7}$$

$$= (wL/Q)\ A\ L^{\alpha-1}K^{\beta} \tag{8}$$

$$= (wAL^{\alpha}K^{\beta})/AL^{\alpha}K^{\beta} = w \tag{9}$$

Thus the marginal productivity of labour will be equal to the wage level provided that competition is perfect. The above will indicate the increase in production which would stem from the input of one additional unit of labour while holding the capital stock as before.
Similarly for capital productivity:

$$\partial Q/\partial K = i \tag{10}$$

This approach was originated as an attempt to verify the marginal productivity theory of distribution: that is that each input would receive the value of its marginal product and that output of each factor would be just exhausted.

From Euler's theorem (Henderson and Quandt, 1958):

$$wL + iK = Q \tag{11}$$

From equations (5) and (6) above:

$$w = \alpha Q/L \tag{12}$$

$$i = \beta Q/K \tag{13}$$

Hence:

$$\alpha Q + \beta Q = Q \tag{14}$$

$$\beta = (1 - \alpha) \tag{15}$$

This would suggest that each input is paid its marginal product and that the total proceeds are divided between labour and capital in the ratio $\alpha$:$(1-\alpha)$ (Henderson and Quandt, 1958). This revised formulation of the production function is normally employed:

$$Q = AL^{\alpha}K^{1-\alpha} \tag{16}$$

This result has been confirmed by a large number of empirical studies conducted in several different countries which indicate that $\alpha + \beta \simeq 1$, and that $\alpha \simeq 0.65$ and $\beta \simeq 0.35$ (Heathfield, 1971). However, some doubt has been cast as to whether the construction industry follows this pattern and it can be argued that the alternative formulation of the Cobb-Douglas production function given in equation (4) is more appropriate. Nevertheless this paper is based on the assumption that $\alpha$ plus $\beta$ is approximately equal to unity.

Thus if the assumptions underlying the above production function are confirmed, this will make it possible to estimate the marginal rates of productivity of capital and labour using average productivity statistics. This conforms to the neo-classical theory of the firm that, under perfect condition, average costs will be equal to marginal costs.

## Total-factor productivity

### *Outline*

To overcome the limitations of the single-factor approaches considered above the total-factor productivity measurement was developed. This approach takes account of all major inputs to the productive process.

From the point of view of productive efficiency under conditions of scarcity, an enterprise will have to combine the various inputs in the correct combination for optimal results to either minimize costs for a given level of production or to maximize production from available resources.

From the point of view of allocative efficiency, the owners of the various factors of production may be assumed to seek to maximize their return from those factors. Under perfect competition those factors will receive their highest prices when in their most productive uses and thus should correspond to optimal productive efficiency.

*The total-factor production function*

Total-factor productivity, in this context, involves the creation of a cost index of production changing with respect to time. Where an enterprise uses several inputs to produce one product, the production function can be represented thus (Millward *et al.*, 1983):

$$Q=f(X_1, X_2, \ldots X_j, \ldots X_n; t) \tag{17}$$

where $X_j$ = input $j$
$t$ = time

The rate of change of productivity with respect to time is given by differentiating the logarithm of the above function with respect to time thus:

$$\frac{\mathrm{d}\ln Q}{\mathrm{d}t}=\frac{\mathrm{d}\ln f(X_1, X_2, \ldots X_n; t)}{\mathrm{d}t} \tag{18}$$

$$=\frac{\partial \ln f}{\partial t}-\sum_{j=1}^{N}\frac{\partial \ln f}{\partial \ln X_j}\frac{\partial \ln X_j}{\partial t} \tag{19}$$

A cost function associated with the above production function can be derived using McFadden's duality theorem (Weber and Lippiatt, 1983):

$$C=g(y_1, y_2, \ldots y_j, \ldots y_n; t) \tag{20}$$

$$C=\sum_{j=1}^{N} y_jX_j \tag{21}$$

where $C$ = total cost of production
$y$ = cost of input $j$

Weber and Lippiatt (1983) have demonstrated that the derivative of the logarithm of the cost function with respect to the logarithm of a particular factor price will give the cost share of that factor:

$$\partial \ln g/\partial \ln y=y_jX_j/C=S_j \tag{22}$$

where $S_j$ = cost share of input $j$

In the two-factor production system assumed above, the production and cost functions can be represented thus;

$$Q=f(L, K; t) \tag{23}$$

$$C=g(w, i; t)=wL+iK \tag{24}$$

From equation (22) above, if $C$ is assumed to be equal to $Q$:

$$\partial \ln g/\partial \ln w=wL/Q=\alpha \tag{25}$$

$$\partial \ln g/\partial \ln i=iK/Q=(1-\alpha) \tag{26}$$

Weber and Lippiatt (1983) argue that the continuous partial derivative $\partial \ln g/\partial \ln y$, can be approximated using discrete data by the ratio of the percentage change in the total cost to the percentage change in the cost of input $j$.

$$\Delta C/\Delta w = C_t - C_{t-1}/w_t - w_{t-1} \simeq \partial \ln g/\partial \ln w \tag{27}$$

$$\Delta C/\Delta i = C_t - C_{t-1}/i_t - i_{t-1} \simeq \partial \ln g/\partial \ln i \tag{28}$$

The rate of growth in the total-factor productivity is approximated by Caves *et al.* (1980) thus:

$$\Delta\mathbf{TFP} = \ln Q_t - \ln Q_{t-1} - \sum_{j=1}^{N} (\ln X_{jt} - \ln X_{jt-1})(S_{jt} + S_{jt-1})/2 \tag{29}$$

where $\Delta\mathbf{TFP}$ = total-factor productivity growth rate

Applying this to the two-factor production model, and assuming that $\alpha$ is a constant, total productivity growth can be taken as:

$$\Delta\mathbf{TFP} = \ln(Q_t/Q_{t-1}) - \alpha \ln(L_t/L_{t-1}) - (1-\alpha)\ln(K_t/K_{t-1}) \tag{30}$$

In this form the calculation of a total-factor productivity index presents no major computational problems provided that the data are available. Annual turnover figures, measured on a 'value added' basis, will be needed for the years being analysed along with average labour employment statistics and estimates for fixed capital investment for each year. If the assumption that $\alpha$ is a constant is dropped then additional statistics will be required for the cost of the factor inputs so as to calculate the index.

Thus, provided that the assumptions of perfect competition and fixed distributional parameters hold, the main problem is not one of computation but of the availability of statistics in the correct form and comprehension of the result.

If an inter-industrial or inter-sectoral comparison was envisaged the model could easily be adapted by taking the variable $t$ as the level of technology rather than as time. While this will also apply to international comparisons, in practice the computation will be very much more complex since differential factor costs will have to be taken into account.

It ought to be emphasized that the anomalies affecting labour and capital productivity in contracting may also lead to unreliable results for total-factor productivity measures.

## Evaluation

### *Measures of productivity*

Problems remain whichever single-factor definition of productivity is employed in that improved labour (or capital) productivity may not necessarily lead to more efficient and cheaper production. In essence productivity growth should not be seen as an end in itself but a means to an end. The objective is usually that of reducing unit costs – productive efficiency – but may also involve dealing with scarcity of resources – allocative efficiency. In the 1950s and 1960s with effective full employment for much of the time, shortage of labour was a seen as a real constraint on economic growth. Consequently, improvements in labour productivity were essential if the economy was to grow faster than the rate of increase in the labour force.

### *Productive efficiency*

Clearly, the total-factor productivity index provides the best indication of the efficiency of the productive process employed – subject to the problems raised above in the case of contracting operations if both the labour employed and capital requirements were very low. However, the question remains as to the relative adequacy of the single-factor productivity measures as substitutes.

From this point of view, if average labour productivity has any relevance, then it must be as a suitable proxy for operational efficiency. In the case of inter-industrial or international comparison (e.g. the UK construction industry *vs* the UK steel industry or the UK construction industry *vs* US construction industry) it will be valid if the capital output ratio is similar and the production process similar. In the case of inter-temporal comparisons (e.g. a study of the UK construction industry over time) average labour productivity will be valid provided that the other factor inputs remain the same. Average labour productivity will be of dubious accuracy in the case of comparing one firm with another because of the possibilities for subcontracting. It has one weakness for international comparisons in that, unlike the other approaches which use pure financial ratios, it will be affected by the rate of exchange for currency. This will make such comparisons less valid during periods of instability in world currency markets.

In terms of the Cobb–Douglas production function, in situations of perfect competition, the marginal revenue product of labour will be equal to the wage rate. From equations (9) and (12) above,

$$\partial Q/\partial L = w = \alpha Q/L \tag{31}$$

Since $\alpha$ – labour's share of gross product – is assumed to be a constant, then the average labour productivity $Q/L$ should be a reasonable proxy for the marginal labour productivity $\alpha Q/L$, provided that $Q$ is presented in value-added format.

Notwithstanding the above, average labour productivity cannot cope with changing technology or factor substitution over time. For example, if the cost of labour increased relative to the cost of capital then substitution of the latter for the former would be expected. This would increase the average labour productivity ratio to reflect the higher wage level but would not necessarily result in cheaper or more efficient production. Equally, in cases where most of the labour was subcontracted, this would provide a rather dubious measure of the operational efficiency of a contractor.

From the point of view of the individual firm, which can be assumed to be a private-sector profit-maximizing organization, capital productivity will provide a better assessment of its efficiency in use of resources. Wasteful use of labour and materials will reflect in profit margins and hence return on capital invested. Labour productivity, no matter how it is defined, cannot reflect inefficiency in the use of other resource inputs. Indeed if there is wasteful use of plant and equipment or of material this will actually result in an increase in labour productivity in that it would increase the 'output' of the firm or industry with no impact on labour input, unless checked by competition (Lowe, 1986b).

From equation (3):

$$\Pi = (1-\alpha)Q \tag{32}$$

Using equation (13):

$$\Pi/K = (1-\alpha)Q/K = i \tag{33}$$

Capital productivity, calculated on an 'internal rate of return' basis, should provide a good estimate for the marginal revenue product of capital ($i$) and is not so dependent on assumptions of perfect competition as average labour productivity. It, nevertheless, suffers from similar weaknesses as labour productivity on the issue of technical change and factor substitution. While capital productivity should provide a fair estimate of the overall financial management of a construction company, it will not be a good guide as to the efficiency of the contracting operations for the reasons stated above.

*Allocative efficiency*

The study of productivity intensified during the period of full employment in the developed world that followed the second world war as 'the new economic problem became that of increasing the yield of available resources' (Salter, 1966).

In this case, total-factor productivity is likely to provide a valid measure of allocative efficiency. If the market structure is near to perfect competition, it may be assumed that the optimal allocation of resources will be ensured by the price paid for the factors of production – labour shortages being reflected by high wages – thus productive efficiency ought to ensure allocative efficiency. In the event of market imperfections leading to welfare loss this will not apply and intervention may be required to correct this imbalance.

Labour shortage was seen as the main constraining factor on economic growth in the immediate post-war period and thus much attention was focused on average labour productivity. As a response to labour shortage, immigration was encouraged to Britain from the new commonwealth and also from Ireland – a traditional source of labour for the UK construction industry ever since the building of the canals and the railways in the 18th and 19th centuries.

However, labour shortage is clearly not the main problem for the situation in the 1980s with mass unemployment throughout much of the developed world. Consequently there is little point in advocating increased mechanization in attempts to raise labour productivity unless this also leads to a reduction in unit costs. Indeed even if it does reduce construction costs it might have adverse implications for life-cycle costing. It can be argued that, all other things being equal, a labour-intensive productive process is actually preferable in terms of job creation.

Notwithstanding the above, it can be argued that, in construction, there are potential shortages of certain skilled operatives and site managerial staff which could act to constrain future construction output. Nevertheless, there is no reason to believe that this cannot be dealt with by a concerted effort in training and retraining.

By contrast, if the current high level of interest rates has any meaning, capital appears to be a more serious constraining factor on economic growth than labour. Certainly high interest rates appear to have the impact of discouraging private sector investment. Perhaps even more significant is the belief, by many western governments, that increases in public sector investment will force up interest rates still higher and 'crowd out' private investment. This has led to the imposition of annual 'cash limits' for public investment in the UK and to corresponding dramatic cuts in public spending on capital projects affecting in particular construction output. Thus for the overall economy, at least in the current economic climate, capital productivity appears a more valid measure of allocative efficiency than labour productivity.

This will affect investment by contractors in plant and facilities in the same way as for other industries. However it must be borne in mind the point raised above regarding the low capital/output ratio in construction.

## Analysis

### *Assessment*

The suitability of conventional labour and capital productivity measurement as indicators of overall performance are, to some degree, dependent on the extent to which the industrial structure of construction corresponds to perfect competition. If it is perfectly competitive then both labour and capital productivity should provide a reasonable yardstick for time-series productivity comparisons provided that no significant technological changes or factor substitution have intervened. They will also be valid for inter-industrial or international comparisons, provided that the productive process is similar in terms of capital/output ratio, level of technology, etc.

If the construction industry departs too far from the perfect competition model, then labour and capital productivity represent little more than measures of labour or capital intensity of the productive process, since the features demonstrated by the Cobb–Douglas production function may no longer apply.

While the construction industry may not be perfectly competitive in all aspects – notably in connection with large-scale building and civil engineering projects where the choice of companies is limited – it is much nearer to the ideal than many other industries. This is illustrated by the UK construction industry which exhibits many of the attributes of perfect competition such as a large number of buyers and sellers, freedom of entry and exit, the absence of technical barriers to expansion, and allocation of work by competitive tender (O'Brien, 1976).

Thus we would expect that there would be a fair degree of correspondence between the overall efficiency of use of capital and the return on capital invested and that capital productivity should provide a reasonable measure of productive and allocative efficiency where appropriate.

Labour productivity should provide a reasonable global measure of productive efficiency under certain circumstances although not suitable for inter-firm comparisons. It should be emphasized, however, that labour-intensive production methods are not inherently inefficient and that some attention should be paid to maintenance costs as well as capital costs when considering productivity performance. It should be remembered that the British taxpayer is still paying the price of the productivity drive in council housing of the 1960s – many of the system built products of which have now been demolished! Thus improvements in quality control must be seen as a major contribution to higher productivity: due either to less abortive work or longer lifespan.

## Conclusion

Any consideration of productivity is bound to be problematical if only because of the problems of definition. Consequently a multiplicity of different definitions have emerged, many of which owed their origins and general relevance to the conditions of a bygone economic era yet which are still quoted by authoritative sources in inappropriate circumstances.

An example of this can be found in the furious debate over local authority direct labour construction departments in the UK, when it was argued that because they were more labour intensive than the average private sector builder that they were consequently inefficient and wasteful of public resources and should be closed down. The above comparisons were made on the basis of average labour productivity measured in terms of gross output/number of operatives employed and took little account of the differing types of work undertaken, the different employment structure, use of subcontract labour and other key issues, between the two sectors (Langford, 1982).

In conclusion it can be argued that the 'productivity' of individual factors of production and inputs are meaningless in themselves unless related to overall production costs. No one would suggest that the GDP of a country should be measured in terms of tonnes of coal mined, barrels of oil, or the numbers of aircraft built; the different components of production have to be brought to a common base by taking monetary values of the outputs. Similarly, the productivity of labour, capital, land, and raw materials need to be aggregated within a financial framework. This would equate to the total-factor productivity approach outlined above.

If lack of information or computational problems rule this method out, while none of the single-factor measures are ideal, the above would suggest that capital productivity expressed in discounted cash flow terms appears to come closest to the above objective. While serious problems exist when using capital productivity to assess the efficiency of contracting operations, other measures have similar problems. It is significant that this is precisely the type of approach that has been selected by the British government for the control of local authority direct labour construction departments despite the low capital base for many and the consequent modest targets. Paradoxically, the legislation followed a debate initially triggered by adverse average labour productivity statistics for the direct labour sector.

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**References**

Caves, D.W., Christiansen, L.R. and Swanson, J.A. (1980) Productivity in US railroads. *The Bell Journal of Economics* **11,** 166–81.

Bowen, W. (1984) The prospects for productivity in Ruckeyser, W.S. *et al.* (eds.) *Working Smarter* (edited by W.S. Ruckeyser *et al.*). Penguin, New York, pp. 1–18.

Harvey, J. (1981) *The Economics of Real Property.* Macmillan, London, pp. 178–9.

Hawkins, C.J. and Pearce, D.W. (1971) *Capital Investment Appraisal.* Macmillan, London. pp. 11–25.

Heathfield, D.F. (1971) *Production Functions.* Macmillan, London, pp. 29–44.

Henderson and Quandt (1958) *Microeconomic Theory: A Mathematical Approach.* McGraw-Hill, New York, pp. 62–7.

Hillebrandt, P.M. (1984) *Analysis of the British Construction Industry.* Macmillan, London, pp. 221–36.

Langford, D.A. (1982) *Direct Labour Organizations in the Construction Industry.* Gower, Aldershot, pp. 47–71.

Lowe, J.G. (1986a) Alternative Approaches to the Measurement of Productivity in the Construction Industry, Paper presented to 10th CIB Congress, Washington, 21–6 September, pp. 3943–3950.

Lowe, J.G. (1986b) Local Authority direct labour construction organisations – an assessment of alternative measures of productivity. *International Journal of Construction Management and Technology*, Vol. 1(2), pp. 30–41.

Metcalf, D. and Richardson, R. (1984) Labour. In *The UK Economy* (edited by A.R. Prest and D.J. Coppock). Weidenfield and Nicholson, London, pp. 243–305.

Millward, R., Parker, D., Rosenthal, L., Sumner, M.T. and Topham, N. (1983) *Public Sector Economics.* Longman, London. pp 225–35.

O'Brien, D.P. (1976) Direct Works Departments: An economic evaluation, some statistics. *National Builder*, September, pp. 296–9.

Rendall, F.J. and Wolf, D.M. (1983) *Statistical Sources and Techniques.* McGraw-Hill, London, pp. 41–52.

Salter, W.E.G. (1966) *Productivity and Technical Change.* Cambridge University Press, Cambridge, p 1.

Sugden, J.D. (1978): Direct labour: how productivity statistics have proved nothing. *Municipal Engineering* 354–71.

Weber, S.F. and Lippiatt, B.C. (1983) *Productivity Measurement for the Construction Industry.* National Bureau of Standards, Washington DC, pp. 12–15.