MEASURING PUBLIC ENTERPRISE PRODUCTIVE EFFICIENCY : A SUGGESTED FRAMEWORK

Edward Scicluna

1. Introduction

In discussing the productive efficiency of public enterprises, the expert group meeting convened by ICPE in November 1981,(1) noted that in the imperfect market conditions prevailing in developing countries, where different factors, including price distortions, have to be taken into consideration, indicators of productive efficiency represent a necessary evaluative tool compensating for the inadequacy of profitability indicators. This need is often highlighted in those instances where public enterprises are entrusted with social goals, particularly in the underpricing of products, which run counter to commercial objectives.

The rationale of this paper is that unless some systematic means of measuring the output and productivity of public enterprises is found, a large proportion of economic activity will remain unaccountable. It is inconceivable that the "efficiency" measures expected of public enterprises by concerned citizens and administrators in developing countries are either non-existent or are so primitive as to give misleading information. Notwithstanding the number of conceptual and methodological problems which abound in this area, it must be realized that parallel attempts are being made by governments and research institutions of advanced industrial countries to measure the productivity of non-commercial public sector activity.(2)

Perhaps the most comprehensive study of public sector (local government) productivity was undertaken by the Urban Institute in conjunction with the National Commission on Productivity.(3) Besides providing an excellent study of the conceptual and methodological problems, it prescribes procedures for monitoring effectiveness of many of the municipal services. The major conceptual contribution of the study is the emphasis on quality and effectiveness rather than just efficiency and quantity. Efforts are made to ensure that output measures represent progress toward end objectives of the services or useful outcomes, and not intermediate results which may or may not positively contribute to the desired objectives. The second conceptual contribution is that of a multiple characteristic output - emanating from the multiple objective nature of the output being produced. Unlike the federal governments exercise in productivity measurement, the Urban Institute does not provide

ECONOMIC AND SOCIAL STUDIES (New Series), Vol. 1, 1982.

a methodological aggregation procedure for measuring the "whole" output. In fact, it argues against it. The result is the production of as many partial productivity measures as the number of output characteristics that could be identified.

"Despite the ease with which such estimates have been made, however, productivity remains one field in which economic statistics have run ahead of economic theory".(4) This statement made some twenty years ago regarding productivity measurements in the commercial sector could not be more adequate today to describe similar attempts now being made in public enterprises. Sometimes, public enterprise managers and government officials have to make do with very crude measures such as the cost per capita or the size of the population being served.

The importance of deriving a set of reliable measures of public sector productivity cannot be minimized. At the practical level one conceives of budget-maximizing bureaucrats with low level of productivity performance being rewarded by higher budget appropriations once this inefficiency remains unmeasured and thus undetected. At the macro level the implications can be more serious. Baumol's model (5) of unbalanced growth dichotomizes an economy into two sectors with unequal productivity growth rates. Postulating that public sector economic activity falls into the low productivity sector and assuming that their wages keep in line with the wage rate set by the private high-level productivity sector, the model predicts a secular rise in public sector costs, subsequently called Baumol's disease. With no reliable estimates of government productivity refuting the relatively low productivity assumption set by Baumol, the implications of the model have obtained a certain amount of credibility.

This brief study is concerned with the possibility of improving the measurement of public enterprise productivity. The first part of the paper reviews briefly some conceptual issues bearing on this subject, while the second part outlines a methodology that overcomes some of the problems inherent in previous work and which has been applied in the more difficult areas of public sector activity. (6)

2. Problems in Productivity Analysis

In order to understand what productivity measures mean, or do not mean, one must consider more carefully just what we are trying to do when we measure productivity in the public sector. "Productivity" means different things to different people. The general form of a productivity index however, is always the comparison of an output-input ratio at a particular point in time and space with a corresponding ratio at another point. Since both outputs and inputs are measured in real terms, the changes in the respective ratios are sometimes referred to as physical productivity. (Only when input prices are constant is a productivity increase reflected in cost reduction). Productivity is thus a measure of the efficiency with which physical inputs are

transformed into physical outputs. How this measure behaves over functions and over time -- and what significance is to be attached to this behaviour -- thus depends upon what inputs are compared with what outputs and upon how inputs and outputs are themselves measured.

Single-factor productivity indexes, such as the familiar labour productivity index used in the government studies cited earlier, do not for example measure how hard or how well civil servants work. The quality and application of workers is of course not irrelevant, but their measured "productivity" is likely to depend more upon the amount and type of capital employed in the activities concerned than on work effort as normally understood. This is indicated, for example, by the reference to the higher measured productivity in the more capital-intensive activities of certain public enterprises. The only way to avoid ignoring the contribution to output of other factors of production which is endemic in such single factor measures is by using a total input (factor) productivity measure such as net or gross total factor productivity. (7) Unfortunately, little progress has yet been made towards constructing such measures in the public sector, in large part owing to our inability to obtain data that accurately measure the output and input variables presumably entering into the production relationship.

The main measurement problems encountered in this task are identification and aggregation (which include the quality control problem). For many organizations it is extremely difficult to identify and measure a physical unit of output. For example, what is the output of a bank: the number of accounts serviced, the number of customers served, the number of transactions, etc.? This problem is often more acute in some public enterprises where the output is a service which can have many dimensions, some of which may be virtually nonquantifiable yet constitute an important part of the output (e.g. development of rural areas). Moreover, few organizations produce a single output; joint production is the norm, not the exception, and the statistical analysis associated with the practical implementation of productivity measurement is greatly complicated by the existence of joint products.

All these problems, while not unique to public sector organizations seem likely to be most acute there. In some public enterprises, direct measures for service are possible (e.g. electricity generation, letters delivered, volume or weight of garbage collected), but in others proxy measures must be used (e.g. number of benefit cheques issued, number of clients), and in still others there appear to be no obvious output measure (e.g. consumer protection, public safety). (8) In all cases, the construction of quality-adjusted output measures over time is difficult (e.g. new facilities of telecommunications are added, garbage collection is moved from the backdoor to the curb).

Multiple outputs are also the norm in the public sector. Different public enterprises have been created to serve different

objectives which often include broad economic objectives ranging from the optimization of public revenues to the stabilization of employment. Some of these pluralistic objectives may often involve important trade offs.

The inherent multiplicity of functions associated with public enterprises in themselves are no cause for confusion. As Vernon remarks "as long as policy makers and scholars can keep the differences (of objectives) in mind, the enterprise can be operated, controlled, evaluated and appreciated according to their respective purpose" (9). In practice, the problem remains as to who is to decide which functions are to be identified as outputs and who is to establish the relative importance of each one of them within the whole output basket. Should it be the consumer, or the public enterprise manager, government or the social scientist?

The aggregation problem arises because of non-homogeneity - it is highly unlikely that each of the physical units of input and output is identical. Person - hours of labour, for example, surely are not the same across individuals because different people have different inherent characteristics (some work well under pressure, some do not) and different acquired characteristics (different amounts and types of education). The problem of aggregating capital of different vintages has received even more attention in the literature, without, however, any apparent satisfactory practical resolution. Even materials aggregation may be difficult: for example, although energy units may be directly comparable (using kilowatt - hours), tons of steel may not be (since there are many different types). Aggregation of some public enterprise output units may present more serious problems - for example assistance to a number of farmers in one area is equivalent to how many farmers in a different area?

Accounting for quality changes is in essence an aggregation problem. To be able to assess changes in productivity for a single output it is necessary to compare measures over time. The output being measured must be identical intertemporally. Productivity gains may be reflected in improvement in output quality, but these will only be reflected in productivity measures if the output measure employed is quality-adjusted.

The change in public enterprise output can thus be defined as an aggregate of appropriately-weighted indexes of quantity and quality characteristics. In the absence of equilibrium market prices, weighting could either be in terms of consumers' marginal utility or producers' marginal cost. The model in the next section of this paper uses the latter set of weights as aggregators.

3. The Joint Production Function Approach

The search for better output proxies for public enterprise activities is normally carried out within the constraints of

available descriptive statistics. One such output proxy measure is the consequence or effectiveness measure associated with a particular public enterprise. Some of the social indicators used fall into this category. Such indicators are readily identified with certain government programmes, and have therefore often been used in the PPBS approach to government budgeting. It is a short but dangerous step to use such indicators as output proxies in productivity analysis, however. Estimating the number of seasonal jobs provided by two different programmes, assuming all other things being equal, may be justified in programme evaluation, but the results over time associated with a given programme as a rule also reflect a changing environment. In evaluating public enterprise performance the November 1981 ICPE expert group meeting stressed the need to separately assess the impact of the external factors and the internal efforts, noting that with regard to socio-economic objectives, public enterprises ought to be considered as only one of the channels to be used in achieving them. Other channels are government departments and the private sector.

A more promising approach to the output measurement problem is that taken by Bradford, Malt and Oates (BMO). (10) BMO emphasize the distinction between "outputs" and "consequences". They call the former D-output and the latter C-output. Let the following be a series of means-end relationships (or production and utility functions):

$$D = f(I)$$
$$C = g(D,E)$$
$$U = u(C,Z)$$

where I represents a vector of inputs, D a vector of direct outputs, and E a vector of environmental factors. Utility (U) is seen as a function of consequences C and a vector Z which represents the level of provision of other public goods and the quantities of private goods consumed by the individual.

Setting out the production process in this simple framework emphasizes the unreliability of using consequences as output proxies in a changing environment. For changes in "consequences" to reflect changes in "output proper", environmental factors must be unchanged during the period of observation.

Unfortunately, useful as it is, this approach too glosses over the subtle differences between "activities" (what BMO call D-output) and "output proper". Identifying activities with output proper seems as confusing as identifying output proper with consequences. Conceptually, the three levels should be kept separate.

The output of a public sector service activity can, for example, be defined in a dual manner -- on the one hand as that outcome (emanating from an activity) which is adjusted for changes in quality or efficiency. The BMO paradigm may be extended by adding "output proper" (D') as follows:

$$D' = f(I)$$
$$D' = g(D,Q)$$
$$C = h(D',E)$$
$$U = u(C,Z)$$

Where, as before, I is a vector of inputs, D is a vector of "direct" or operational outputs and C, U, E and Z are also defined as before. D' is then a vector of outputs "proper". The output of a public enterprise may thus be defined on the one hand as that outcome or consequence (emanating from an activity) which is adjusted by the exclusion of environmental factors and on the other hand as that activity or output which is adjusted by the inclusion of quality measures. If quality (Q) is unchanged, then D' becomes equivalent to D, and if the environment (E) is also unchanged, D' becomes equivalent to C.

In this framework, BMO s direct output (D) which is really an aggregation of activities, becomes a measure of intermediate output. Using this measure as a proxy for final output assumes that efficiency changes in the second stage of the service production function -- the relation between D and D' -- are, by definition, nil.

Since D' output as such is not directly observable, the best proxy may be defined as a weighted aggregate of (direct) output and quality characteristics. To measure output in this sense, one therefore needs to identify, measure and aggregate these characteristics. Each of these methodological stages will now be considered in turn.

The delineation of an output into a collection of elements or characteristics is an approach which Lancaster (12) has suggested in his "New Theory of Demand". The main technical novelty lies in breaking away from the traditional approach that goods are the direct objects of utility and instead, postulate that it is the properties or characteristics of the good from which utility is derived. To move towards multiple characteristics has the important advantage of incorporating many of the intrinsic qualities of individual goods. Scattered through the literature are a variety of approaches similar in nature to that of Lancaster. Becker's version (13) in terms of a household-production function is more comprehensive since it also includes time as one of the function's components. At the more empirical level is the hedonic price indexes literature pioneered by Griliches (14) which assumes that a commodity can be viewed as a bundle of characteristics or attributes for which implicit prices can be derived from prices of different versions of the same commodity containing differing levels of specific characteristics. The authors distinguish between the physical characteristics of a good and its performance variables (15). Both sets of variables are considered. This "characteristics approach" forms the conceptual base for the framework of this study. Both goods and services may be conceived as baskets of characteristics. In the case of goods, these characteristics or speci-

fications can be standardized. In the case of services, such standardization is very difficult and many times impossible to achieve. A food manufacturer can turn out one million loaves of bread with the same weight, texture, and nutritious value. A bank manager cannot guarantee the same levels of service throughout the day (let alone throughout the year).

In fact goods may be physically measured in terms of one unit or characteristic -- such as number, weight, length or volume -- because it can safely be assumed that all the other characteristics are held constant. This aspect is fundamental to the traditional theory of consumer behaviour which has survived on the proposition that "goods are what are thought of as goods" (16). This has not been possible with services. Since services must be simultaneously consumed as they are produced, standardization of many of the characteristics cannot be achieved. It can no longer be assumed that all the other characteristics are held constant.

We are now in a position to define quality and workload. Quality may be defined as an aggregate measure of all the characteristics of a good or service other than the one being used primarily for identification. In the case of goods, a primary measure could be the weight, length or volume or simply the number of relevant units. In the case of services, the unit of measurement could be the number of persons being served, but other units may also be used. The primary measure of a service will be referred to as the workload. The output may then be defined as a weighted aggregate of workload and quality characteristics (17).

Which characteristics are best suited as workload units and which as quality characteristics will depend on the service being measured. Certain services are more amenable to measurement than others due to their easily measurable workload component and to their negligible (and sometimes constant) quality characteristics. Very often these are the services which affect a person indirectly. Refuse collection, water distribution and mosquito eradication programmes fall into this category. Tons of refuse collected, cubic feet of water used, and percentages of mosquitoes eradicated respectively are possible units of measurement. Quality dimensions may or may not be present. In the case of refuse collected, a quality dimension could be the location of the pick up service -- the curb or the backyard, for example. Services delivered directly to persons, such as hospitals and educational services are more difficult to measure since it is not obvious what and how many characteristics are to be identified for measurement. The contention of this study is that there is no short cut to this identification and measurement problem. Each public enterprise to be evaluated needs to be thoroughly studied and examined within the suggested framework in order that a satisfactory number of characteristics are identified and made operational.

The final methodological step in measuring a public sector output

is the aggregation of output and quality characteristics into an output index. This problem regarding which functional form is best suited as an aggregator and what meaning should be given to it needs to be solved satisfactorily. In fact, certain ambiguity in relation to this aspect has severely troubled the hedonic price literature. The function suggested here is not a hedonic price function and will therefore avoid the problems of functional specification and interpretation faced by the latter.

4. Empirical Estimation of Productive Efficiency

With regard to the specification and interpretation of the functional form for aggregating the workload (or output) and quality characteristics suggested above, we turn to the economic theory of joint production functions. Since most public enterprises are involved in the production of multiple goods and services, a multiproduct production function approach offers a suitable framework for deriving such a measure.

The production process of public enterprises may be conceived as separable into two stages. In the first stage, the public enterprise "manager" maximizes an aggregated input index (consisting of labour, capital and materials), subject to a budget and factor prices constraint. In the second stage, the "manager" is concerned with maximizing the enterprise output (consisting of products, workload and quality characteristics). The flow of external pressures (the environment) places a demand on the enterprise's resources and could therefore be included in the function (18).

Based on the assumption of separability between the output and input aggregator functions, one can then derive a productivity index (19), defined as a ratio of these two functions.

5. Conclusion

Instead of being left to operate on the basis of tradition, public enterprise managers are today being expected to account for differences in performances very often based on piece-meal indicators. When considering the multiple objectives nature of public enterprises and the problems associated in evaluating productive efficiency in such enterprises, one should consider the approach suggested in the paper as an alternative framework worthy of further investigation.

Dr. E. Scicluna is Head, Public Administration Division, Faculty of Management Studies, University of Malta.

Notes

1. UNIDO - ICPE Export Group Meeting on the Changing Role and Function of the Public Industrial Sector in Development, Vienna, Austria, October 1981.

2. By 1976 the productivity of about two-thirds of federal government operations in Canada and the U.S. was already measured and evaluated. See for example Treasury Board, Government of Canada (1976) Ottawa; Performance Measurement in the Public Service of Canada, and Joint Financial Management Improvement Program, Reports on Federal Productivity (Annual Report) Washington D.C.; U.S. Government Printing Office.

3. Hatry H.P., L.H. Blair, D.M. Fish, J.M. Greiner, J.R. Hall, and P.S. Schaenman, (1971). How Effective are your Community Services? Washington D.C.: The Urban Institute and the International City Management Association.

4. Kendrick, John W., (1961) "Introduction: Productivity and National Income Accounting". Conference on Research in Income and Wealth, Output, Input, and Productivity Measurement, N.B.E.R., Studies in Income and Wealth, Vol. 25, Princeton University Press.

5. Baumol, William J., (1967) "Macro-economics of Unbalanced Growth: The Anatomy of Urban Crisis" American Economic Review, 57 (June): 415 - 26.

6. For the results of applying this approach to municipal police services, see Scicluna E. (1982). The Measurement of Output and Productivity in the Public Sector: Police Services, Ph.D. dissertation, The University of Toronto.

7. In the single output - multiple input case, total factor productivity can be defined as a ratio of output to an aggregated index of inputs, and productivity changes (measured as a percentage), can be measured by the difference between output change and an aggregation of input changes. To see this, denote output by Y, inputs by Xj (j = 1.....k) and productivity by P so that the single output production function can be written in implicit form as F (Y,X1 ... Xk,P) = 0. If this is separable into three components (output, inputs, and productivity), it can be written as Y - PF' (X1...Xk) = 0. Total factor productivity is then defined as the ratio P = Y/F'(X1....Xk). If F' is linear homogeneous and represents the least - cost input combination, then P is equivalent to Hicks-neutral technical change and

$$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \sum_{j=1} Sj \frac{\dot{Xj}}{Xj}$$

where Sj is the share of input-j in total cost. Productivity change is therefore a difference between an output change and an aggregate of input changes.

8. It should be noted, however, that some such activities may be characterized in terms of the nonoccurrence of undesired events (accidents, crime); for some stimulating suggestions on how to approach this problem, see Shoup, C.S. (1969) Public Finance. Chicago : Aldine.

9. Vernon, R. and Y. Aharoni (Eds) (1981) State Owned Enterprise in the Western Economies London, Croom Helm.

10. Bradford, D.F., R.A. Malt and W.E. Oates, (1969), "The Rising Cost of Local Public Services: Some evidence and Reflections", National Tax Journal, 22 (June): 185 - 202.

11. Having distinguished these two concepts of output, BMO suggest that for police services, whose inputs (I) are presumed to involve people, cars and communications systems, "the resulting vector D of direct outputs might include as components the number of city blocks provided with a specified degree of surveillance (by patrolmen on foot or automobile patrols), the number of blocks provided with readily available police-officer reserves, the number of intersections provided with traffic control, and so on." This study considers the latter as activities rather than "output proper".

12. Lancaster, Kelvin J. (1971), Consumer Demand: A New Approach, New York: Columbia University Press.

13. Becket, Gary S. (1976) The Economic Approach to Human Behaviour, Chicago Press.

14. Griliches, Zvi (ed.), (1971) Price Indexes and Quality Change, Cambridge, Massachusetts: Harvard University Press.

15. In the case of a car, physical characteristics (or specifications) are such things as horsepower, weight and length while acceleration, handling, steering, accommodation and fuel economy are performance variables.

16. Lancaster, Ibid.

17. Workload and direct outputs will henceforth be used interchangeably. Obviously the term workload applies to those enterprises which are producing services to the community.

18. If these environmental factors are operational and are included in the model, the resulting productivity measures would obviously have a different meaning from those measures where such factors are excluded.

19. The input aggregator function is derived through the estimation of the cost share equations based on the optimality conditions of the constrained maximization of the input index. The output aggregator function is based on the input index produced by the cost share equations parameters.

References

Baumol, W. J. (1967) "Macro-economics of Unbalanced Growth: The Anatomy of Urban Crisis", American Economic Review, 57 (June), 415 - 26.

Becket, G. S. (1976) The Economic Approach to Human Behaviour, Chicago, Chicago Press.

Bradford, D. F., Malt, R. A., and Oates, W. E., (1969) "The Rising Cost of Local Public Services: Some Evidence and Reflections", National Tax Journal, 22 (June), 185 - 202.

Griliches, Z. ed: (1971) Price Indexes and Quality Change, Cambridge, Massachusetts, Harvard University Press.

Hatry, H. P., Blair, L. H., Fish, D. M., Greiner, J. M., Hall, J. R., and Schaenman P. S., (1971), How Effective are your Community Services?, Washington D. C., The Urban Institute and the International City Management Association.

Kendrick, J. W. (1961) "Introduction: Productivity and National Income Accounting". Conference on Research in Income Wealth, Output, Input and Productivity Measurements, N.B.E.R. Studies in Income and Wealth Vol 25, Princeton University Press.

Lancaster, K. J. (1971) Consumer Demand: A New Approach, New York, Columbia University Press.

Scicluna, E. (1982) The Measurement of Output and Productivity in the Public Sector : Police Services. Ph.D dissertation. The University of Toronto.

Shoup, C. S. (1969) Public Finance, Chicago, Aldine.

Vernon, R. and Aharoni Y. eds. (1981) State Owned Enterprise in the Western Economics, London, Crown Helm.