

Efficiency Measurement in the Local Public Sector: Econometric and Mathematical Programming Frontier Techniques

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Local government in advanced economies is undergoing a period of rapid reform aimed at enhancing its efficiency and effectiveness. Accordingly, the definition, measurement and improvement of organisational performance is crucial. Despite the importance of efficiency measurement in local government it is only relatively recently that econometric and mathematical frontier techniques have been applied to local public services. This paper attempts to provide a synoptic survey of the comparatively few empirical analyses of efficiency measurement in local government. We examine both the measurement of inefficiency in local public services and the determinants of local public sector efficiency. The implications of efficiency measurement for practitioners in local government are examined by way of conclusion.

EFFICIENCY IN LOCAL GOVERNMENT REFORM

Public sector reform has now been underway for more than a decade in many developed countries and shows few signs of abating. Typically reforms have been directed at reducing the size of the public sector and increasing its efficiency. For instance, in the United Kingdom a vigorous program of privatisation has taken place and the civil service has been radically restructured through the *Next Steps* initiatives, with numerous services previously provided by public agencies at the central and local government level competitively tendered and contracted out to private firms. Similarly, in Canada a comprehensive reform program designed to improve public sector performance has been followed under the *Public Service 2000* program. In Australia, the Commonwealth Public Service has experienced dramatic changes over the period from 1983 to 1993.

In the United States, the quest for a government that “works better and costs less” has been assigned a high priority by the Clinton administration and the resultant *National Performance Review* taskforce has instigated a new system of performance assessment. But the most far-reaching and comprehensive program of public sector reform has been adopted in New Zealand, which has developed the concept of the ‘contract state’. The similarities in the public sector reform programs followed in these countries, with their typical mix of commercialisation, corporatisation, deregulation of public sector management, performance monitoring and contracting-out, clearly all seek to enhance efficiency in the public sector. Evaluating the success of these programs depends crucially on how accurately and appropriately efficiency can be measured, and this forms the focus of the present paper which seeks to survey the empirical analyses of efficiency measurement in local government.

This work is important because it is only relatively recently that attempts have been made to apply econometric and mathematical frontier techniques to the efficiency of local governments in the provision of local public services. Indeed, whilst the application of efficiency analysis to private sector activity, especially in the area of financial services, are now commonplace, comprehensive studies of public sector efficiency at any level are rare. However, the need for the application of improved productivity measurement in the public sector appears indisputable, especially as policy-makers' interest in public outcomes has grown with the scale of the resources involved.

The paper itself is divided into five main areas. The first section examines the nature of local government performance measurement and the inherent difficulties involved in this process. The second section briefly discusses the theoretical basis of frontier efficiency measurement techniques. The third section examines the literature in the empirical measurement of inefficiency in local public services. The fourth section discusses the determinants of local public sector efficiency. The paper ends with some brief concluding remarks.

THE NATURE OF LOCAL GOVERNMENT PERFORMANCE MEASUREMENT

Local government service delivery has come under increased scrutiny with the ongoing process of reform. In the absence of contestable markets, and the information and incentives provided by these markets, performance information, particularly measures of comparative performance, have been seen as a means by which interested parties can gauge the provision of local government services. The potential users of this information are threefold. Firstly, the recipients (or clients, users, customers or consumers) of these services can use this publicly available information to exercise client choice more effectively, and ensure the transparency and accountability of service providers for taxpayer funds. Second, the providers or purchasers of services, governments, departments and service providers, can also make use of performance measures. Possible uses include the stimulation of policy development by highlighting influences on the operating environment, facilitating the monitoring of public sector managerial performance, and the promotion of 'yardstick' or benchmark competition for improving performance in areas where there is little competition in markets for inputs and/or outputs. These measures can also be used as an analytical tool in examining relationships between alternative agencies and programs and as a means of assisting resource allocation by way of linking allocated funding with agency and/or program objectives. Finally, performance measurement can be used as a managerial decision-making tool. Attention can thereby be focused on practices in similar organisations that may assist the attainment of agency/program objectives, and thus facilitate programs of performance improvement.

The problem of measuring the performance of private or public sector organisations is fundamental to any economy concerned with the accountability, transparency, efficiency and effectiveness of these institutions. In the private sector it has long been assumed that, in the long run, the discipline imposed by the marketplace motivates corporations to strive for cost efficiency and profit maximisation, facilitated by feedback from the markets for capital, corporate control and managerial labour. These include measures derived from profits, rates of return on assets, investment and invested capital, market shares and market power.

In contrast, the local public sector is generally seen to lack both an analogue for profit-seeking behaviour and an adequate feedback system to assess the quality of decisions. It is argued that there are five main aspects of government services that may make it difficult to develop accurate performance indicators. First, the outputs of a service provider may be complex and/or multiple (Mark, 1986; Hatry and Fisk, 1992). Furthermore, there may be

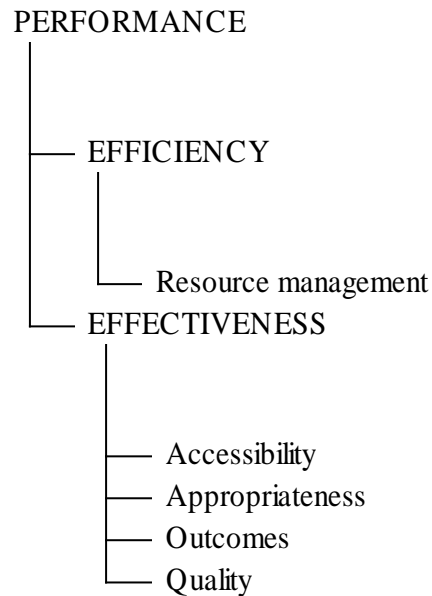
difficulty in establishing cause and effect between the activities of a service and the final outcomes it seeks to influence, and these may be evident only after considerable time (SCRCSSP, 1998: 7). Second, government organisations may encounter problems in identifying the cost of producing and delivering services (Ammons, 1986, 1992; Ganley and Cubbin, 1992). For example, there may be difficulty apportioning costs across different services or the costs of a given program over long periods of time. Certainly, this problem has been mitigated by the introduction of systems of management accounting and accrual accounting (SCRCSSP, 1998a: 7). Third, complexity in government services may exist due to the interplay of related services and programs (Epstein, 1992; Carter, Klein and Day, 1995). For instance, performance indicators may need to capture the positive and negative spillover effects of service provision (SCRCSSP, 1997: 16). Fourth, there are potentially many users of governmental performance information. Different lines of accountability and the disparate informational requirements of government, taxpayers, employers, staff, consumers and contractors create additional complications in performance measurement (SCRCSSP, 1997: 16). For example, the Australian Industry Commission's (1997: 58) report on Australian local government performance indicators received a number of submissions suggesting that the "most relevant measure for the Commonwealth and state governments may be a financial measure, but for local government and its community stakeholders it is [the focus] on outcome measurements and the effectiveness of resource inputs". Finally, a number of restrictions placed by these stakeholders may impinge upon the theoretical ability of government entities to improve performance, and therefore bring the orientation of performance information into question. For example, Ammons (1986: 191) argued that the intergovernmental mandating of expenditures and intergovernmental grant provisions may restrict the ability of government bodies to modify behaviour, whereas Miller (1992) maintains that the budget process itself has an important contribution to the notion of performance.

Many of these characteristics are closely aligned with Wolf's (1989) four basic attributes of nonmarket or public sector supply. Firstly, he argues that "nonmarket outputs are often hard to define in principle, ill-defined in practice, and extremely difficult to measure as to quantity or to evaluate as quality" (Wolf, 1989: 51). Accordingly, inputs generally become a proxy measure for output (Dollery and Worthington, 1996b: 29). Secondly, nonmarket outputs are usually produced by a single public agency, often operating as a legally constituted monopoly. The resultant lack of competition makes meaningful estimates of economic efficiency difficult, and consequently obscures allocative and productive efficiencies. Thirdly, Wolf (1989: 52) argues that the "technology of producing nonmarket outputs is frequently unknown, or if known, is associated with considerable uncertainty and ambiguity". This may serve to further obscure notions of performance in the local public sector. Finally, Wolf (1989) proposes that nonmarket production activity is also usually characterised by the lack of any 'bottom-line' evaluation mechanism equivalent to appraising success. Moreover, there is often no specified procedure for terminating unsuccessful production (Dollery and Worthington, 1996b: 29).

One generic assessment framework that has been widely used in public sector services is detailed in Figure 1 (Industry Commission, 1997; SCRCSSP, 1998). The approach is largely based upon the premise that in order to analyse performance a suite of outcome indicators should be considered collectively. Overall performance is divided into two components: (i) efficiency, which describes how well an organisation uses resources in producing services; that is, the relationship between the actual and optimal combination of inputs used to produce a given bundle of outputs, and (ii) effectiveness, the degree to which a system achieves its program and policy objectives. In turn, effectiveness encompasses a

number of different desired aspects of service linked to program outcome objectives. These are: (i) appropriateness (matching service to client needs); (ii) accessibility (aspects such as affordability, representation amongst priority groups and physical accessibility); and (iii) quality (the process of meeting required standards or incidence of service failures).

FIGURE 1 *Framework for performance assessment*



However, this framework, whilst comprehensive, is argued to suffer from a number of limitations. First, some authors have argued that the traditional public sector performance framework is too narrowly focused. For example, Carter, Klein and Day (1993: 37) support an additional category in the form of ‘economy’ with an exclusive focus on “the purchase and provision of services at the lowest possible cost consistent with a specified objective”. Some authors have proposed restricting effectiveness to measuring the achievement of targets or objectives, and introducing ‘efficacy’ so as to measure the impact of services on the community. Still others have supported a similar argument for ‘equity’, so as to highlight the distinction between administrative and policy effectiveness. However, Carter, Klein and Day (1993) argue that doing so may increase the focus of effectiveness on administrative effectiveness and reduce the incentive to produce ‘efficacy’ and ‘equity’ or policy-related outcomes.

A second problem is that the generic performance framework makes no specific allowance for identifying additional variables relating to efficiency and the still largely unmeasured concept of effectiveness (Mann, 1986). These ‘contextual’ variables include environmental characteristics relating to the input/output set and the task environment, individual characteristics such as motivation and incentive, and structural characteristics relating to the degree of centralisation, hierarchy and leadership style (Johnson and Lewin, 1984: 230). For example, the Australian Industry Commission (1997: 53) has argued that contextual information serves two main purposes.

First, it clarifies the environmental constraints on performance, aiding interpretation of the indicators. Second, it helps ensure that what is being reported as an indicator of performance is not merely an indicator of activity. For example, expenditure per capita on a particular service is not an indicator of performance unless the nature of the service is tightly defined.

Alternatively, Ammons (1992: 119) has argued that contextual information forms 'barriers' to performance analysis. That is, 'environmental barriers', such as political factors and intergovernmental relations, 'organisational barriers', including inadequate information systems and bureaucratic structures, and 'personal barriers' such as managerial risk avoidance, implies that the concept of public sector 'performance' will always be compromised by largely unmeasured sets of contextual information.

In practical terms, the lack of treatment of contextual information is likely to affect interpretation in three ways. Firstly, "organisations may pursue different objectives and this may be important when assessing services designed to local preferences" (SCRSSP, 1998: 18). Ignoring these differences could stifle local initiative and encourage uniformity, even when this is clearly inefficient. Secondly, the clients of services may differ across jurisdictions. For example, an increase in the aged proportion of the population in a local government area can affect the measured efficiency of aged community services. Finally, organisations may face different input prices (even when these can be accurately measured) or operate at different scales of operation. For instance, it is to a service provider's advantage to ensure its operations are of optimal size: that is, neither too small if there are increasing returns-to-scale, nor too large, if there are decreasing returns-to-scale. Clearly, an appropriate performance framework should take account of factors which affect a local government's measured efficiency.

The final problem is that the framework defined above effectively serves to 'disaggregate' performance. This makes the job of selecting and calculating partial performance measures more tractable. For example, it is possible to incorporate both qualitative and quantitative aspects of service quality, and incorporate partial measures of efficiency such as outputs per unit of input. Yet it is also obvious that local governments are multi-dimensional entities: a single measure is unlikely to reflect the complexity of decision-making or the scope of a council's entire activities. Furthermore, even when individual measures are combined using some weighting system, the resultant composite measure is ultimately arbitrary, and unlikely to be replicated in any systematic manner. A related issue is that the process of 'disaggregation' of performance often serves to introduce some confusion into the process of performance assessment. For example, the division between efficiency, an essentially inward looking form of measurement of the council's own operations, and effectiveness, an outward perspective to the impact of services upon the community, has caused some confusion (Epstein, 1992: 167). However, on this point the Australian Industry Commission (1997: 103) maintained that:

There can be debate about whether various indicators measure effectiveness or efficiency, but the classification adopted is not crucial to the value of having an overall framework which serves to ensure that all aspects of performance are assessed in an integrated way. The same types of indicators will always be relevant.

Notwithstanding the complexities of performance measurement in the local government context, as we have seen numerous pressures exist (and are likely to continue) which oblige the local government sector to provide transparent assessments of the efficiency of its

operations. The use of frontier efficiency measurement techniques represents a theoretically well-developed and statistically advanced method of determining both the absolute and relative economic efficiencies of particular local government jurisdictions. We now examine this methodology in some detail.

THE THEORY OF MICROECONOMIC EFFICIENCY MEASUREMENT

Economists have developed three main measures of efficiency. Firstly, technical or productive efficiency refers to the use of productive resources in the most technologically efficient manner. Put differently, technical efficiency implies the maximum possible output from a given set of inputs. In cost terms, this means that an organisation should produce a specified level of output in the cheapest possible manner. Secondly, allocative efficiency refers to the distribution of productive resources amongst alternative uses so as to produce the optimal mix of output. In other words, allocative efficiency is concerned with choosing between the different technically efficient combinations of outputs. Taken together, allocative efficiency and technical efficiency determine the degree of economic efficiency. Thus, if an agency uses its resources completely allocatively and technically efficiently, then it can be said to have achieved total economic efficiency. Alternatively, to the extent that either allocative or technical inefficiency is present, then the organisation will be operating at less than total economic efficiency. Thirdly, and in contrast to both allocative efficiency and technical efficiency, dynamic efficiency is a much less precise concept. In general, dynamic efficiency refers to the economically efficient usage of scarce resources through time and thus embraces allocative and technical efficiency in an intertemporal dimension.

The empirical measurement of economic efficiency centres on determining the extent of either allocative efficiency or technical efficiency or both in a given organisation or a given industry. Economists have employed production possibility frontiers, production functions and cost functions in their attempts to measure efficiency in actual organisations and industries. Production possibility frontiers map a locus of potentially technically efficient output combinations an organisation is capable of producing at any point in time. To the extent an organisation fails to achieve an output combination on its production possibility frontier, and falls beneath this frontier, it can be said to be technically inefficient. Similarly, to the extent to which it produces some combination of goods and services on its production frontier, but which do not coincide with the wants of its clients (usually expressed in terms of the prices they are willing to pay), it can be said to be allocatively inefficient. Production functions provide an analogous means of relating inputs to outputs in a production process by including input prices. Cost functions transform the quantitative physical information in production frontiers into monetary values. Cost functions can thus convey information about the allocative and technical efficiencies of organisations in pecuniary terms.

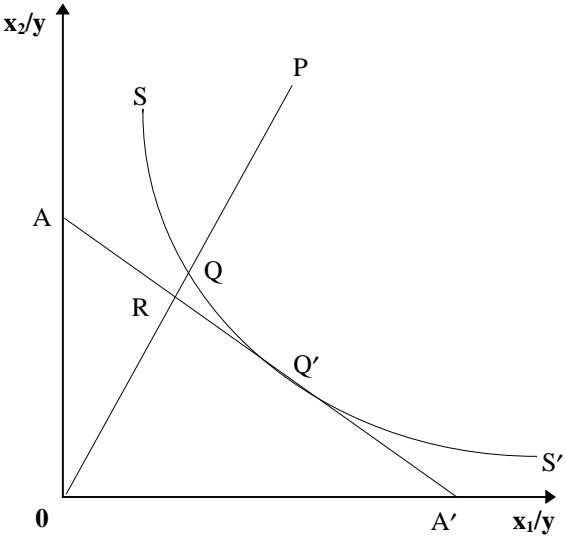
Accordingly, if we can determine production frontiers, production functions, or cost functions that represent total economic efficiency using the best currently known production techniques, then we can use this idealised yardstick to evaluate the economic performance of actual organisations and industries. By comparing the actual behaviour of organisations against the idealised benchmark of economic efficiency we can determine the degree of economic efficiency exhibited by some real-world agency. This general approach to efficiency measurement has been termed the 'deterministic frontier approach' (DFA). However, it may well be that deviation away from a given efficiency frontier may be due not to inefficiency by the organisation in question but rather external factors beyond its control. This has led to the

development of the ‘stochastic frontier approach’ (SFA) which seeks to take these external factors into account when estimating the efficiency of given real-world organisation.

In contrast to both the DFA and SFA techniques, which attempt to determine the *absolute* economic efficiency of organisations against some given benchmark of efficiency, the ‘data envelopment analysis’ (DEA) approach seeks to evaluate the efficiency of an organisation *relative* to other organisations in the same industry. DEA thus calculates the economic efficiency of a given organisation relative to the performance of other organisations producing the same good or service rather than against an idealised standard of performance. An important variant of the DEA methodology often employed in the analysis of economic efficiency in the public sector is known as the ‘free-disposal hull’ (FDH) approach. This technique has the advantage of being able to determine existing best-practice in an industry on the basis of fewer observations and it does not assume the existence of many different ways of producing some good or service. We will return to these four different methods of measuring efficiency in our discussion of the literature on the empirical measurement of inefficiency in local public services below.

In essence, the literature on frontier production and cost functions and the calculation of efficiency measures begins with Farrell (1957). Whilst the empirical estimation of production functions had begun long before Farrell’s paper, Farrell (1957) made the first tentative steps in adapting these to rigorous microeconomic analysis.

FIGURE 2. *Technical, allocative and total efficiency*



In parenthesis for technically inclined readers, Farrell’s (1957) argument is contained in Figure 2. Here two inputs, x_1 and x_2 , are utilised to produce a single output y , so that the production frontier is $y = f(x_1, x_2)$. If we assume constant returns to scale (where the relationship between output y and inputs x_1 and x_2 does not change as the inputs increase), then $1 = f(x_1/y, x_2/y)$. The isoquant of the fully efficient firm SS' permits the measurement of technical efficiency. An isoquant is a locus of points representing a given level of output (say, 100 units of y) using different combinations of the two inputs x_1 and x_2 . Now, for a given firm using quantities of inputs $(x_1^* x_2^*)$ defined by point $P (x_1^*/y, x_2^*/y)$ to produce a unit of output y^* , the level of technical efficiency, or the ability of a firm to maximise output from a given set of inputs, may be defined as the ratio OQ/OP which measures the proportion of (x_1, x_2) actually necessary to produce y^* . Thus $1 - OQ/OP$, the technical inefficiency of the firm, measures the proportion by which (x_1^*, x_2^*) could be reduced (holding the input ratio x_1/x_2

constant) without reducing output. It also measures the possible reduction in the cost of producing y^* . Finally, given constant returns to scale, it roughly estimates the proportion by which output could be increased, holding $(x_1^* x_2^*)$ constant. Point Q , on the other hand, is technically efficient since it already lies on the efficient isoquant.

If the input price ratio AA' (which computes the prices of inputs x_1 and x_2) is known, then allocative efficiency [referred to by Farrell as price efficiency], or the ability of a firm to use these inputs in optimal proportions, given the respective prices at point P , is the ratio OR/OQ , and correspondingly the allocative inefficiency is $1 - OR/OQ$, where the distance RQ is the reduction in production costs which would occur if production occurred at Q' – the allocatively and technically efficient point, rather than Q – the technically efficient, but allocatively inefficient point. Hence, total economic efficiency [referred to by Farrell as overall efficiency] is the ratio OR/OP , and total inefficiency is $1 - OR/OP$ which is the possible reduction in cost from moving from P (the observed point) to Q' (the cost minimising point); the cost reduction achievable is the distance RP . As we have seen, technical efficiency can be decomposed as the product of technical and allocative efficiency; and total inefficiency can be decomposed roughly as the sum of technical and allocative inefficiency.

Of course, these measures of efficiency have been defined on the assumption that the standard of efficient production is known. Farrell (1957) suggested the use of several known and observable production techniques to estimate this isoquant. It is this suggestion that efficiency could be measured against an idealised frontier isoquant that then forms the basis of subsequent empirical analysis. More detailed analyses of the theoretical foundations of microeconomic efficiency measurement may be found in Charnes, Cooper, Lewin and Seiford (1993), Fried, Lovell and Schmidt (1993) and Fare, Grosskopf and Lovell (1994).

MEASURING EFFICIENCY IN LOCAL PUBLIC SERVICES

As we have seen within the theoretical framework detailed, at least four different approaches have been employed in the analysis of local public sector efficiency. These are: (i) the deterministic frontier approach (DFA); (ii) the stochastic frontier approach (SFA); (iii) the data envelopment analysis or DEA approach; and (iv) the Free Disposal Hull or FDH approach. Table 1 includes details on these several approaches.

Firstly, as we observed earlier the deterministic frontier approach is an econometric technique which assumes that all deviations from the frontier are the result of inefficiency: that is, inefficiencies are embedded in a strictly one-sided disturbance term. Studies by Bjurek, Hjalmarsson and Forsund (1990) and De Borger and Kerstens (1996a) have used this approach. Secondly, as we have seen the stochastic frontier approach is also an econometric technique, though it assumes a two-component error structure so that the inefficiencies usually follow an asymmetric half-normal distribution and the random errors are normally distributed. Examples of work in this area include Viton (1992), Deller and Halstead (1994) and Vitaliano (1997). Thirdly, in line with our earlier comments the DEA approach is a mathematical programming technique which assumes that all deviations from the estimated frontier represent inefficiency. This approach has been applied to local governments by Cook, Roll and Kazakov (1990), Rouse, Putterill and Ryan (1995) and Worthington (1999). Finally, as we have noted earlier the FDH approach is a variant of DEA that allows the assumptions concerning the production technology to be kept to a minimum. Examples of work using this approach include Tulkens (1993), De Borger, Kerstens, Moesen and Vanneste (1994) and De Borger and Kerstens (1996b).

Firstly, a number of studies have used stochastic frontiers (either cost or production) to analyse the efficiency of the local public sector. For example, Hayes and Chang (1990) used a sample of 191 U.S. municipalities to test efficiency differences between 'city manager' and 'mayor-council' forms of government. Formulating a cost frontier, they obtained total costs for three categories of local public sector output (ie. fire, police and refuse collection) and specified outputs in terms of the number of respective employees. The price of capital was proxied by the municipalities' bond rating and the price of labour by the average municipal employee's salary. They found that the mean cost efficiency of mayor-council municipalities (84.78 percent) was higher than that of city-manager type councils (81.21 percent). Put differently, mayor-council municipalities could reduce costs by 15.22 percent and produce the same level of output, while city-manager councils would need to reduce total costs by 18.79 percent to become purely cost efficient.

Subsequent to Hayes and Chang (1990) a number of studies also examined municipal service efficiency employing stochastic frontiers. Using this approach, Steven Deller made an extended inquiry into the efficiency of municipal road services in both Illinois, Minnesota and Wisconsin (Deller and Nelson, 1991; Deller, 1992; Deller, Nelson and Walzer, 1992) and Maine, New Hampshire and Vermont (Deller and Halstead, 1994). In the latter study a cost frontier was used, with the cost of capital proxied by the weighted average of new capital items, the price of labour by wages, and output by the length of roads under municipal jurisdiction. In the former studies, standard production frontiers were employed. In these cases there was an attempt to incorporate quality considerations into municipal output, with roads defined as being gravel, or low or high-volume bituminous roads. Regional cost-of-living indices were also included. The resultant empirical evidence indicated *mutatis mutandis* that current expenditures on rural low-volume road service were unnecessarily high because of managerial inefficiencies: in particular, "efficiency measurements suggested that costs could be reduced, on average, to 45 percent of current levels" (Deller, Nelson and Walzer, 1992: 364).

Secondly, an increasing number of studies have employed the nonparametric technique of data envelopment analysis to investigate local public sector efficiency. Cook, Roll and Kazakov (1990) used DEA to measure the relative efficiency of Ontario's highway maintenance patrols. The inputs in this case were patrol maintenance and capital expenditures (along with an allowance for environmental factors) and the outputs were stipulated in terms of the characteristics of the roads serviced and an accident prevention factor. The resulting efficiency scores were then used to classify maintenance patrols into a number of classes for analytical purposes. One finding was that the technical efficiency of patrols where the proportion of 'privatised' work was 20 percent or more was higher than those patrols with less than 20 percent of privatised work.

An identical theoretical framework and sample was subsequently employed in Cook, Kazakov, Roll and Seiford (1991), and Wade, Kazakov and Roll (1993). Bjurek, Kjulín and Gustafsson (1992) examined the technical and scale efficiency of Swedish public day-care centres. Inputs were defined in terms of the number of hours worked by pre-school teachers, nurses and cooking cleaning staff, and outputs denominated by the capacity of children, aged up to two years, and from 3 to 6 years. Hjalmarsson and Veiderpass (1992) examined the efficiency of 285 Swedish public electricity distributors. Inputs included the discretionary levels of labour, and the non-discretionary length of transmission lines and transformer capacity, and the outputs were specified in terms of both volume of kilowatts and the number of customers. Hjalmarsson and Veiderpass (1992) found only modest efficiency differences between public and private electricity distributors.

DEA has also been used in a study of New Zealand local authority road maintenance by Rouse, Putterill and Ryan (1995). Conceptually very similar to the earlier stochastic frontier work of Deller (1992) and the nonparametric approaches of Cook, Roll and Kazakov (1990) and Cook, Kazakov, Roll and Seiford (1991), the study incorporated environmental factors as major cost and process drivers. The empirical analysis contained an index of road surface defects and a measure of 'roughness' for both urban and rural roads. For the measures obtained under the assumption of variable returns-to-scale, 39 of a possible 62 transport local authorities were judged to be 100 percent technically efficient, with 12 below 70 percent, and the remainder between 70 and 100 percent efficiency.

Finally, more recent work has employed the FDH approach to efficiency measurement, and has been based largely on studies of Belgian municipalities, with a focus on cost efficiency. De Borger and Kerstens (1996: 149) argue that this approach is closely related to the nature of the data:

A consequence of the Belgian institutional framework is that the sample does not contain input price variability. There is no wage flexibility as salary scales of municipal personnel are completely fixed. Moreover, all municipalities have access to the same capital market, and in fact obtain most of their funds from one and the same specialised financial institution. Therefore, the assumption of identical input prices across municipalities may not be too unreasonable. Consequently, throughout the analysis we focus on the measurement of cost efficiency.

Within this approach, and those followed by Vanden Eeckaut, Tulkens and Jamar (1993) and De Borger and Kerstens (1996a, 1996b), the inputs into the FDH model are total municipal expenditures. The outputs are denoted in terms of variables intended to reflect the responsibilities of Belgian municipal governments. These include total population, length of roads, number of persons aged over 65 years, those living on subsistence grants, the number of students enrolled in local public schools, and the maintenance of recreational facilities. The results indicate that mean relative cost efficiency scores range from 0.57 to 0.94. Put simply, inputs (and therefore costs) could be reduced anywhere from 6 percent to 43 percent across Belgian councils. Moreover by using FDH the measure of performance is drawn from the actual sample so that cost efficient councils can easily be identified for benchmarking. In addition, productive efficiency frameworks have also been used to test the relative efficiency of the same sample of Belgian municipalities. De Borger, Kerstens, Moesen and Vanneste (1994) employed an analogous conceptualisation of outputs, although inputs were measured in terms of white and blue-collar employee and capital stock (proxied by the surface area of municipal-owned buildings). Significantly, De Borger and Kerstens (1996a; 1996b), amongst others, attempt to incorporate the multiple-outputs produced by Belgian municipal governments into a single measure of efficiency. This stands in stark contrast to the other work on public sector efficiency which focused on specific aspects of service provision, such as roads, schools, welfare services and transportation [see, for example, Bjurek, Kjulin and Gustafsson (1992), Tulkens (1993), Rouse, Putterill and Ryan (1995)].

At least three aspects of the efficiency measurement of local public services deserve further attention. These are: (i) the appropriateness and sensitivity of efficiency measures to the postulated reference technology, (ii) the appropriate treatment of non-discretionary inputs/outputs in local public services, and (iii) the choice of input or output orientation in efficiency measures. First, several studies have analysed the efficiency of local governments using a broad variety of reference technologies [see, for instance, Bjurek, Hjalmarsson and Førsund (1990), Vanden Eeckaut, Tulkens and Jamar (1993), and De Borger and Kerstens

(1996a)]. In a study of Belgian municipalities, De Borger and Kerstens (1996a) used both parametric (deterministic and stochastic frontiers) and non-parametric (FDH and DEA) methods to evaluate the sensitivity of the rankings of municipalities with respect to the underlying reference technology. They observed that not only may the shape of the efficiency distribution be affected by the use of different approaches, but that they can also alter the implied rankings of individual observations. Using Spearman rank correlation and Pearson product moment correlation coefficients, they demonstrated that statistically significant differences existed between FDH and DEA, whilst “DEA has a slightly higher similarity in ranking relative to the [parametric approaches]” (De Borger and Kerstens 1996a: 159). The estimated range of mean efficiency scores also was quite large, with cost efficiency measures between 0.59 and 0.83. Using these observations, De Borger and Kerstens (1996a: 167) concluded, “it would seem prudent to analyse efficiency questions using a broad variety of methods to check the robustness of the results”.

Vanden Eeckaut, Tulkens and Jamar (1993) undertook a similar comparison. However, their results were disaggregated on the basis of expenditure classifications, and thereby indicate how consistency between rankings may vary over the sample. Comparing FDH and DEA under variable returns-to-scale, constant returns-to-scale and non-increasing returns-to-scale assumptions, they found that all three DEA methods yielded similar results for large expenditure class municipalities. Some 15 to 22 percent were found to be cost efficient. For the second expenditure class some divergence between the methods was found, and accordingly, concordant rankings and mean efficiency scores were once again established.

Second, the standard Charnes, Cooper and Rhodes (1978) and Banker, Charnes and Cooper (1984) model formulations implicitly assumed that all inputs and outputs are discretionary (i.e. controlled by the management of each municipality and varied at its discretion). In most circumstances we would expect that this assumption would not hold for the local public sector. For example, in a technical efficiency formulation the geographic, environmental and demographic characteristics of a given municipal area are important inputs into the process of providing local public services, yet they are also exogenously fixed and thereby nondiscretionary. Alternatively, in a cost efficiency model [such as those employed by De Borger and Kerstens (1996a)] the outputs of the local public sector relate directly to the demographic and socioeconomic characteristics of the municipality. The usual case is that these outputs, both quantitatively and qualitatively, are largely imposed by some minimum state or national legislation.

Two approaches are available to purge efficiency measures of these exogenously fixed nondiscretionary inputs and/or outputs. The first method is to incorporate these assumptions into a single-stage procedure following Banker and Morey (1986) and Golany and Roll (1993). Efficiency measures thus obtained are based on the premise that for an input(output)-oriented model, it is not relevant to maximise the proportional decrease (increase) in the entire input (output) vector. Rather maximisations should only be determined with reference to the sub-vector that is composed of discretionary inputs (outputs). Examples of this approach include Worthington's (1999) analysis of New South Wales local government libraries, where the nondiscretionary inputs include socioeconomic, demographic and geographic characteristics.

The second method uses a ‘two-stage approach’. In the first stage, a frontier model in which only factors under a municipality's control are included as inputs in computing efficiency scores. In the second stage, those efficiency scores obtained are regressed on factors beyond a municipality's control. The difference between the computed efficiency score from the first stage and its predicted value from the second stage. The residual is used as an index

for measuring 'pure' technical efficiency, which could be attributable to management. Examples of this kind of work include De Borger and Kerstens (1996a).

The final issue revolves around the selection of an input or output orientation in efficiency models. For instance, in an input orientation focus falls on the proportional reduction of inputs to achieve efficiency, whereas in an output orientation emphasis is placed on the proportional augmentation of outputs. Although many contributions to the performance literature on the local public sector have focused on input efficiency measures [see Hayes and Chang (1990) and Vanden Eeckaut, Tulkens and Jamar (1993)], the use of the output orientation is not unknown [see, for example, Deller (1992)]. Whilst the exact formulation will depend on a particular empirical context, De Borger and Kerstens (1996b: 11) reason as follows:

In principle, the choice of orientation should be inspired by the postulated underlying behavioural mode. If one assumes that local governments take outputs as exogenous (for example, determined by citizen's demand) and have substantial control over inputs, then an input orientated measure seems appropriate. Input measures can then detect failures to minimise costs resulting from discretionary power and incomplete monitoring, and provide an indication of possible cost reductions. If on the other hand municipalities have limited control over inputs and face fixed budgets, then an output oriented approach may be quite informative. Output measurement can then identify municipalities that fail to maximise the quantity of the local public services subject to the budget they face, and provide indications of the increase in outputs that could potentially be realised.

DETERMINANTS OF LOCAL PUBLIC SECTOR EFFICIENCY

In contrast to other areas where frontier efficiency measurement techniques have been employed, hypotheses to explain variation in local public sector efficiency are relatively underdeveloped. However, three exceptions should be noted. These include empirical research relating to the impact of political factors, community characteristics, and the impact of financial structure on local public sector efficiency.

Firstly, a number of studies have postulated a relationship between the political composition of the municipal council and the level of efficiency. For example, Vanden Eeckaut, Tulkens and Jamar (1993) generate evidence for the case that political majorities are an explanatory factor for observed inefficiencies. Using municipalities in the (French-speaking) Région Wallone area of Belgium, they obtained data on the three major national political parties (Parti Socialiste, Parti Social Chrétien, and Parti Réformateur Liberal) and local parties, and categorised municipalities in terms of coalition composition, party majority and strength and mayoral affiliation. Their results indicate that the proportion of inefficient municipalities is lowest for liberals and socialists, followed by anti-socialist (majorities obviously formed to exclude socialists), local parties, and finally tripartite coalitions. However, municipalities with liberals and socialists in the majority also have the highest proportion of efficient municipalities "by default": that is, whilst they do constitute the frontier, they do not dominate any interior municipality. Vanden Eeckaut, Tulkens and Jamar (1993: 317) note that "this finding qualifies somewhat the superiority of their performance relative to other parties".

De Borger, Kerstens, Moesen and Vanneste (1994) further emphasised the contention that a politician's emphasis on political rather than economic rationality is likely to contribute

to inefficiency. They postulate that the influence of political agents on bureaucratic selection and the use of explicit and implicit log-rolling may be an important factor in this process, which in turn is construed to be a function of the size of political coalitions. Expounding no compelling *a priori* argument for party-related inefficiency, they incorporate a qualitative variable for liberal and socialist party coalitions, and a quantitative variable for the number of coalition partners in a tobit censored regression model. The results indicate that the number of coalition partners does not exert an influence on municipal efficiency, although the presence of liberals tends to decrease technical efficiency, while the presence of a socialist party does not seem to have any statistically significant effect.

Secondly, several studies have incorporated community characteristics in two-stage efficiency models. For example, De Borger and Kerstens (1996a) incorporate the use of per capita income on the grounds that 'bureaucratic slack' increases with organisational income. In other studies they also include the proportion of the population with a primary (De Borger, Kerstens, Moesen and Vanneste, 1993) or higher (De Borger and Kerstens, 1996b) education qualification to quantify political participation. Only in the case of the latter is their hypothesis (ie. that education increases efficiency) confirmed. In the analysis of a specific local government function, namely library services, Worthington (1999) specified municipal population and area, the proportion of the population from various groups (non-English speaking background, aged and students) and an index of socioeconomic disadvantage as relevant community characteristics. Worthington (1999: 41) concluded, "the study reinforces the importance of taking into account the imposed conditions that impinge upon a given local government's ability to perform efficiently".

Vitaliano (1997) used a stochastic cost frontier to analyse the technical efficiency of U.S. public libraries with an expanded set of public choice-type determinants. These included the percentages of total funding derived from local sources, gifts and investments. His study concluded that "government-run libraries are 2.7% more inefficient than private not-for-profits. And donated resources and greater reliance on local taxation are linked to less inefficiency" (Vitaliano, 1997: 640). Lastly, a number of studies use a broad demographic indicator, either total population (De Borger, Kerstens, Moesen and Vanneste, 1994) or population density (De Borger and Kerstens, 1996a). The basic argument is that a low population level may inhibit exploiting economies of scale in some or all of the production processes. Equivalently, the cost of provision will rise with lower population density. Both of these studies concluded that increases in actual population and population density are associated with improvements in efficiency.

The final set of explanatory variables employed relates to the fiscal parameters of the local public sector. For example, high tax prices may enhance the monitoring process of constituents. Likewise, the well-established and extensively surveyed fiscal illusion literature indicates that misperceived fiscal parameters, like total per capita tax burdens or total expenditure outlay; may increase local expenditure, and accordingly be associated with inefficiency [see Dollery and Worthington (1996a)]. De Borger, Kerstens, Moesen and Vanneste (1994) and De Borger and Kerstens (1996a) use the size of intergovernmental grants to present a case for the influence of the flypaper effect in particular. The results in both cases are generally similar to those of De Borger, Kerstens, Moesen and Vanneste (1994: 353) where "grants may not only encourage local service provision, but that they also lead to some additional technical inefficiency...the local tax rates that we experimented with failed to produce significant estimates".

CONCLUDING REMARKS

Whilst relatively underdeveloped, especially when compared to the extensive financial services literature, a good foundation for frontier efficiency measurement of local public sector efficiency has nevertheless been laid. Problems do remain. For example, the appropriate behavioural specifications to employ, problems with unmeasured inputs and outputs, and the choice between alternative computational techniques. However, these are no more insurmountable than related issues that have arisen in the adjacent fields of financial services, health, education, amongst others. To some extent, the lessons learned from these related areas serve as useful pointers to solutions in the analysis of local public sector efficiency. That said, empirical analysis of local public sector efficiency suggests that it is a unique product of complex non-discretionary inputs and outputs and constraints, multiple-inputs and outputs, and inherently complicated political, institutional and cultural factors.

What implication can then be drawn from the preceding discussion of frontier efficiency measurement for practitioners in local government? In the first place, despite significant technical advances in the application of frontier efficiency measurement techniques to the local public sector, as we have seen there are important caveats in the manner in which their results should be treated. For example, most efficient measurement methodologies embody both discretionary variables (ie. those variables which can be controlled by management) and non-discretionary variables (ie. those variables which are exogenously determined and cannot be influenced by management). Obviously the spatial distribution of local government (with attendant differences in climatic conditions, socioeconomic characteristics of the jurisdictional population, regional input price variations, etc.) and structural constraints imposed by higher levels of government (competitive tendering procedures, accounting methodologies, rate-capping, etc.) can greatly influence the efficiency of local government operations. Likewise, the idiosyncrasies arising from elected municipal councils (political interference with operational matters, special interest considerations, etc.) imply that local government managers are once again constrained by a host of non-discretionary factors in arriving at efficient outcomes. Accordingly, frontier efficiency measurement techniques that do not explicitly acknowledge the significance of these factors should be treated with caution.

Secondly, the complex politicised milieu of local government implies that the effectiveness of services is at least as important as economic efficiency in gauging the success of specific municipalities facing different demands. Frontier efficiency measurement is concerned only with the dimensions of economic efficiency and takes no account of the effectiveness of service provision. It is thus, at best, only a partial view of the operations of councils.

Notwithstanding these caveats, frontier efficiency measurement techniques are increasingly applied to local governments throughout the developed world. The results of these statistical exercises will surely continue to show differences in efficiency within and between local authorities. Moreover critics of local government will doubtless seize on results of this kind as a means of attacking existing service provision and its management. Clearly, familiarity with frontier efficiency measurement techniques and their drawbacks will assist local government practitioners in dealing with this kind of criticism.

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TABLE 1. *Applications in local public services*

Author(s)	Methodology ^a	Sample ^b	Inputs, outputs, explanatory variables ^c	Analytical technique	Main findings
Domberger, Meadowcroft and Thompson (1986)	Cost function	305 U.K. local authorities, 1983-85.	Total costs of refuse collection. Frequency of collection, method of pickup, density of units, distance to disposal points, percentage of household units, amount of waste paper reclaimed, number of abandoned vehicles collected and bottle-banks operated, average earnings of manual workers, dummy variable for tendered contract or 'in-house' services.	Interpretation of parameter estimates, distributional analysis.	Costs significantly lower for tendered collection services. Tendering results in a significant improvement in efficiency.
Deller, Chicoine and Walzer (1988)	Cost function	1,799 Illinois, Minnesota, Ohio and Wisconsin municipalities, 1982.	Total costs, hourly wage rates, input prices for materials and operations, regional cost-of-living index, replacement prices for earth graders and trucks, index of utilisation and intergovernmental road aid. Miles of paved, aggregated surface, and low and high bituminous surface roads.	Interpretation of parameter estimates.	Joint use of inputs produces lower overall costs, emphasis on local government consolidation or contract tendering to capture scale economies.
Charnes, Cooper and Li (1989)	DEA	28 Chinese cities, 1983/84.	Number of industrial staff and workers, amount of 'circulating' capital and total annual wage bill, investment on capital construction of state-owned units and acquisition of machinery and fixed assets for collective units. Gross industrial output value, profits and taxes generated by state-owned enterprises, retail sales.	Descriptive analysis across time and interpretation of scale economies.	DEA as a tool to identify technical inefficiencies in centrally-planned cities.
Bjurek, Hjalmarsson and Forsund (1990)	DEA and deterministic frontier	392-462 Swedish local social insurance offices, 1974-84.	Number of working days, capital (proxied by office space and computer terminals). Income evaluation assessments, sickness reports and control minor reimbursements of personal outlays, evaluation of pension and social insurance payments.	Descriptive and diagrammatic analysis.	Differences in efficiency due to different scale and transformation properties.
Cook, Roll and Kazakov (1990)	DEA	244 Ontario highway maintenance patrols, 1990.	Maintenance and capital expenditures, climatic factor. Area served factor (including length of road section, shoulder width, road service type, winter operations and number of lanes), average traffic served, pavement rating change factor and accident prevention factor (number of road accidents).	Descriptive analysis, comparison of efficiency across privatised/non-privatised patrols.	Use of DEA for peer group comparisons.
Grosskopf and Yaisawarng (1990)	DEA	49 Californian municipalities, 1982,	Aggregate total and variable costs. Capital outlays, police and fire employment.	Interpretation of parameter estimates and efficiency indexes.	Economies of scope, and therefore case for specialisation or diversification.
Hayes and Chang (1990)	Stochastic frontier	191 U.S. municipalities, 1982.	Total costs (fire, police and refuse collection), cost of capital (municipal bond rating), cost of labour (average salary), percentage of owner-occupied housing, minority households, population aged over 25 years, and fire rating. Number of police, fire and refuse collection employees.	Descriptive analysis, ANOVA, Median and Kruskal-Wallis tests of efficiency between mayor-council and city manager-type municipalities.	No difference in the efficiency of different municipal government structures.

Author(s)	Methodology ^a	Sample ^b	Inputs, outputs, explanatory variables ^c	Analytical technique	Main findings
Cook, Kazakov, Roll and Seiford (1991)	DEA	244 Ontario highway maintenance patrols, 1990.	Maintenance and capital expenditures, climatic factor. Area served factor (including length of road section, shoulder width, road service type, winter operations and number of lanes), average traffic served, pavement rating change factor and accident prevention factor (number of road accidents).	Descriptive analysis and comparison of efficiency scores across privatised/non-privatised patrols and traffic level.	Use of DEA in not-for-profit setting.
Deller and Nelson (1991)	DEA	446 Illinois, Minnesota and Wisconsin municipalities, 1990.	Number of full-time equivalent labour, road graders, single-axle trucks, amount of purchased surface material, price of labour (average annual salary), price of capital (fixed proportion of depreciated capital values), price of surfacing material (estimates of material requirements for re-surfacing projects), regional cost-of-living indexes. Miles of gravel, and low and high bituminous roads.	Descriptive analysis on sample disaggregated by mileage range, Anova, Wilcoxon, van der Waerden and Savage tests of efficiency equality across mileage ranges.	Increases in jurisdictional size associated with improvements in efficiency.
Bjurek, Kjulin and Gustafsson (1992)	DEA	194 Swedish public day-care centres, 1988/89.	Number of hours worked by pre-school teachers, nursery nurses and cooking and cleaning personnel, size of centre in square metres. Full-time equivalent capacity, 0-2 years and 3-6 years. Days worked by substitute teachers and nurses, mean parental income, years of experience of centre director, index of director co-operation.	Second-stage tobit regression.	DEA assessment of efficiency in bureaucratically-controlled units. Role of administrative staff in efficiency.
Chang and Kao (1992)	DEA	5 Taipei municipal bus firms, 1956-88.	Capital (number of buses in operation), number of full-time equivalent labour, amount of diesel fuel used. Vehicle kilometres, revenue, number of bus traffic trips on routes.	Descriptive analysis and Wilcoxon, Mann-Whitney tests of efficiency differences over time and private/public firms.	Publicly-owned bus firms increased efficiency after liberalisation of bus routes.
Deller (1992)	Stochastic frontier	1,319 Illinois, Minnesota and Wisconsin municipal areas, 1982.	Number of full-time equivalent labour, road graders, single-axle trucks, amount of purchased surface material, price of labour (average annual salary), price of capital (fixed proportion of depreciated capital values), price of surfacing material (estimates of material requirements for re-surfacing projects), regional cost-of-living indexes. Miles of gravel, and low and high bituminous roads.	Descriptive analysis on sample disaggregated by mileage range, Anova, Wilcoxon, van der Waerden and Savage tests of efficiency equality across mileage ranges.	Need for productive efficiency of local government due to federal policy and fiscal pressures.
Deller and Rudnicki (1992)	Cost function and stochastic frontier	147 Maine public elementary schools, 1985-89.	Average total school expenditure costs, average daily attendance, male and female teacher salaries, administration expenses per pupil, operations and maintenance expenditures per pupil. Cumulative test achievement scores.	Interpretation of parameter estimates, second-stage OLS regression on school size.	Managerial inefficiencies may be incorrectly attributed to size economies. Consolidation may be inappropriate.

Author(s)	Methodology ^a	Sample ^b	Inputs, outputs, explanatory variables ^c	Analytical technique	Main findings
Deller, Nelson and Walzer (1992)	Stochastic frontier.	435 Illinois, Minnesota and Wisconsin municipal areas, 1982.	Number of full-time equivalent labour, road graders, single-axle trucks, amount of purchased surface material, price of labour (average annual salary), price of capital (fixed proportion of depreciated capital values), price of surfacing material (estimates of material requirements for re-surfacing projects), regional cost-of-living indexes. Miles of gravel, and low and high bituminous roads.	Disaggregation of efficiency index across township road size.	High cost inefficiencies, gains in efficiency largely possible through input consolidation.
Hjalmarsson and Veiderpass (1992)	DEA	285 Swedish retail electricity distributors, 1985.	Hours worked by all employees, kilometres of low-voltage and high-voltage electricity power lines, total transformer capacity. Consumption of low-voltage and high-voltage electricity, numbers of low-voltage and high-voltage electricity customers.	Descriptive analysis.	Impact of not-for-profit constraints on efficiency of municipal distributors, modest difference between public and private firms.
Viton (1992)	Stochastic frontier	289 U.S. multi-modal transit firms, 1984-1986.	Total operating expenses. Motorbus, rail, streetcar, trolleybus vehicle miles, hourly wage rates, ratio of peak operating fleet to base operating period, speed of transport (ratio of vehicle-miles to vehicle-hours), dummy variable for transport-type.	Interpretation of parameter estimates, implied impact of single-firm municipal consolidation.	Economies of scope exhausted before scale economies are attained. Consolidation will reduce cost only in limited circumstances.
Tulkens (1993)	FDH	Brussels buses, streetcars and subway, 1977-89.	Total hours of labour worked, energy (in kWh), number of seats-vehicles. Number of monthly seat-kilometres.	Descriptive analysis over time.	Application of efficiency concepts to transportation efficiency.
Vanden Eeckaut, Tulkens and Jamar (1993)	FDH and DEA	235 Belgian municipalities, 1986.	Total costs, Total population, length of roads in municipality, numbers of persons aged over 65 years, beneficiaries of minimal subsistence grants, crimes reported, students enrolled in local primary schools. Dummy variables for socialist, liberal, anti-socialist, local, and coalition dominated municipalities.	Disaggregation of efficiency scores across political majorities.	Multi-party, local coalition-led municipalities less efficient than single-party, national led ones.
Wade, Kazakov and Roll (1993)	DEA	62 Ontario highway maintenance patrols, 1990.	Maintenance and capital expenditures, climatic factor. Area served factor (including length of road section, shoulder width, road service type, winter operations and number of lanes), average traffic served, pavement rating change factor and accident prevention factor (number of road accidents).	Descriptive analysis and comparison of efficiency scores across privatised/non-privatised patrols and traffic level.	Unbounded DEA will not satisfactorily account for real-life situations.
De Borger, Kerstens, Moesen and Vanneste (1994)	FDH	589 Belgian municipalities, 1985.	Number of white-collar and blue-collar municipal employees, capital stock (proxied by surface area of municipal owned buildings). Municipal road surface, numbers of beneficiaries of minimal subsistence grants, students enrolled in local primary schools, surface of area of public recreational facilities, ratio of non-residents to residents in municipality. Dummy variable for liberal or socialist party as ruling coalition, average personal income, block grants, proportion of population with higher education, total population.	Descriptive analysis, second-stage tobit regression.	Scale and fiscal revenue capacity are important determinants of efficiency.

Author(s)	Methodology ^a	Sample ^b	Inputs, outputs, explanatory variables ^c	Analytical technique	Main findings
Deller and Halstead (1994)	Stochastic frontier	104 Maine, New Hampshire and Vermont municipalities, 1987.	Total road costs, labour wages, price of grader and single-axle-dump truck, cost of capital (weighted average of new capital items by municipal bond interest rate). Miles of roads under town jurisdiction. Chief engineers formal training, educational level, years of experience and age.	Interpretation of parameter estimates, Anova, Wilcoxon, van der Waerden and Savage tests of efficiency equality across characteristics of chief engineer.	Placing of rural road maintenance in municipalities highly-inefficient. Positive outcomes from higher levels of training.
Rouse, Putterill and Ryan (1995)	DEA	62 New Zealand territorial local authorities, 1993/94.	Total expenditure on reseals, rehabilitation, and general maintenance, index of environmental factors. Kilometres of road resealed and rehabilitated, general maintenance expenditure, annual vehicle kilometres, roughness index for urban and rural roads, index of road surface defects.	Interpretation of efficiency scores across a number of input-output specifications.	Insights into local authority efficiency by partitioning measures across efficiency, effectiveness and economy.
De Borger and Kerstens (1996a)	FDH, DEA, deterministic and stochastic frontiers.	589 Belgian local governments, 1985.	Total expenditure. Number of beneficiaries of minimal subsistence grants and students enlisted in local primary schools, surface area of public recreational facilities, total population and proportion of population over 65 years. Per capita personal income, municipal property tax rate, per capita block grants, number of coalition parties in government, dummy variable for liberal or socialist ruling party, proportion of adults with primary education as highest qualification, population density.	Descriptive analysis, Spearman and Pearson correlation coefficients between efficiency measures, second-stage tobit regression.	Rank correlation between parametric and nonparametric measures low. Local tax rates and education influence efficiency positively, per capita grants and income negatively.
De Borger and Kerstens (1996b)	FDH	589 Belgian local governments, 1985.	Total municipal expenditures. Surface of municipal roads, number of beneficiaries of minimal subsistence grants, students enrolled in local primary schools, surface area of public recreational facilities, total population and proportion of population aged over 65 years. Municipal property tax rate, per capita block grants, number of coalition parties in government, dummy variable for liberal or socialist ruling party, proportion of adults with higher education as highest qualification.	Descriptive analysis, second-stage tobit regression.	Substantial differences in inefficiency measures possible. Fiscal revenue capacity and grants an important determinant of efficiency.
Vitaliano (1997)	Stochastic frontier	235 U.S. public libraries, 1992.	Total costs (excluding capital equipment), librarian starting salary wage rate, director's salary wage rate. Total circulation of books and serials, weekly hours of operation, number of books added to collection each year. Dummy variable for municipal or private not-for-profit library, percentage of local funding, gifts and investments, population served.	Second-stage tobit regression.	Government -run libraries are more inefficient than private not-for-profits. Donated resources and reliance on local taxation linked to less inefficiency.
Vitaliano (1998)	DEA	184 New York state public libraries, 1992.	Total holdings (books, audio-visual, maps, etc.), hours of operation, new books purchased, total serial subscriptions. Total circulation, reference questions answered. Manager and director salaries, public or association control (city, town, village, other), population.	Second-stage tobit regression.	Association libraries relatively more efficient. Dominant determinant of inefficiency are excessive opening hours.

Author(s)	Methodology ^a	Sample ^b	Inputs, outputs, explanatory variables ^c	Analytical technique	Main findings
Worthington (1999)	DEA	168 NSW local government libraries, 1993.	Population, area, proportion of population NESB, aged, or student, proportion of non-residential borrowers, socio-economic index, gross library expenditure. Library issues. Library expenditure and issues per capita, geographic categories.	Spearman rank correlation amongst efficiency indexes. Second-stage logistic regression.	Case for exogenous factors and scale effects to be incorporated into DEA.

Notes: (a) DEA – Data Envelopment analysis, FDH – Free Disposal Hull; (b) Singular dates represent calendar or financial year cross-sections, intervals represent time-series; (c) Ranked in order by paragraph.