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Explaining differences in productive efficiency: An application to Belgian municipalities

B. DE BORGER[1], K. KERSTENS[2], W. MOESEN[3,1] and J. VANNESTE[1]
[1] *University of Antwerp;* [2] *KUB, Brussels;* [3] *KUL, Leuven*

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Abstract. The purpose of this paper is to measure and explain variations in productive efficiency of municipal governments in Belgium. Technical efficiency is evaluated using a non-parametric method based on the Free Disposal Hull (FDH) reference technology. We first calculate input, output, and graph Farrell efficiency measures for a cross-section of all 589 Belgian municipalities. In a second stage of the analysis we explain the calculated differences in efficiency in terms of variables related to the structural characteristics of municipalities and to the institutional environment.

1. Introduction

An abundant literature deals with measuring efficiency in both the private and the public sector and compares their relative performance (see, e.g., Atkinson and Halvorsen, 1986: 281–294; Borcherding, Pommerehne and Schneider, 1982: 127–156; Färe, Grosskopf and Logan, 1985: 89–106). The efficiency of the local public sector has not been studied equally intensive, however. Although a number of studies are concerned with evaluating productivity growth in state and local governments (see, e.g., Fisk, 1983; Hulten, 1984: 256–266), with the exception of several very recent studies relatively little is known about the degree of technical efficiency involved in the provision of local public services.[1] This is somewhat surprising since technical efficiency is a crucial component of the overall performance of the local public sector. Although performance evaluation in principle requires the identification of all relevant objectives, it has been argued that technical efficiency is compatible with the realization of a variety of other goals that have explicitly or implicitly been attributed to the public sector.[2] A better understanding of the degree of technical efficiency and its determinants is therefore an important first step in global performance evaluation.

In this paper we study productive efficiency of municipal governments in Belgium. We thereby proceed in two steps. We first measure technical efficiency using a deterministic and non-parametric method based on the Free Disposal Hull (FDH) reference technology suggested by Deprins, Simar and Tulkens

(1984; 243–267). The FDH is based on minimal assumptions with respect to the production technology. Moreover, it has a strong intuitive appeal and requires a minor computational effort. In a second stage of the analysis we attempt to explain the variability in technical efficiency among municipalities in terms of their structural and political characteristics, taking into account the institutional framework of local government financing.

The paper is organized as follows. In Section 2 we present the FDH reference technology and discuss three alternative Farrell measures that will be used to evaluate technical efficiency. Application of the suggested methodology to all Belgian municipalities is reported in Section 3. We provide information on the distributions of the calculated efficiency measures for a number of different specifications of the vector of municipal inputs and outputs. In Section 4 we report on our attempt to explain the variability in productive efficiency within the framework of a censored regression model. Potential determinants of productive inefficiency are derived from the literature and from the Belgian institutional environment. The final section summarizes and suggests some conclusions.

2. The FDH-approach to technical efficiency

In this section we discuss the procedure used to measure technical efficiency of Belgian municipalities. To fix ideas, note that the concept of productive or technical efficiency relates to the ability of a production unit to produce on the boundary of its production possibilities set. In this paper we follow the typical procedure in the non-parametric literature and evaluate technical efficiency in two sequential steps. First, we carefully specify the set of production possibilities and its boundary. This defines the reference technology. Second, we use Farrell-type measures to relate the input and output vectors of observed production units to the postulated boundary of the production set. In the remainder of this section we discuss each of these steps in more detail.

2.1. Definition of the FDH reference technology

With respect to the specification of the production set and its boundary a variety of methods have been suggested. At the risk of oversimplifying an impressive literature it is convenient to distinguish between parametric and non-parametric approaches. In the former case it is assumed that the boundary of the production possibilities set can be represented by a frontier of a known functional form with constant parameters.[3] The non-parametric approach on the other hand concentrates on the regularity assumptions of the production set and does not postulate a particular functional boundary. Imposing some plausible restrictions on the nature of the production process a piecewise linear reference technology or best practice frontier is directly constructed on the basis of observed input and output combinations.[4]

In this paper we use the non-parametric FDH reference technology introduced by Deprins, Simar and Tulkens (1984: 243–267) and further popularized by Tulkens and his collaborators (for a review of recent applications see, e.g., Tulkens, 1990). Compared to other non-parametric methods such as Data Envelopment Analysis (DEA) the FDH approach allows us to restrict the assumptions with respect to the production technology to a minimum. Apart from some standard regularity assumptions (e.g. boundedness and closedness of the production set)[5] the only additional assumptions are strong free disposability of inputs and outputs.

Strong free disposability of inputs or monotonicity rules out that an increase in inputs results in a decrease in outputs. Strong free disposability of outputs implies that any reduction in outputs remains producible with the same amount of inputs. Note that the latter assumption allows for variable returns to scale. The property of strong free disposal has a strong intuitive appeal. Given any particular combination of inputs and outputs a production unit must always be capable of producing less output with the same amount of inputs or producing the same output level with a larger amount of inputs.

A graphical illustration of the construction of the free disposal hull for the case of the one input and one output is provided in Figure 1. Reflecting free disposability, each observed combination of inputs and outputs adds one orthant, positive in the inputs and negative in the outputs, to the production set. The free disposal hull FDH is then the boundary to the union of all orthants whose origin coincides with an observed vector. Note that the FDH approach results in a staircase shape of the best practice production frontier. Contrary to other non-parametric approaches, convexity is not imposed.

In practice two methods are available to reconstruct the FDH reference technology and to distinguish efficient from inefficient observations (see Tulkens, 1990 for details). First, it has been shown that FDH may be considered a special case of Data Envelopment Analysis and that the frontier can be obtained by solving an appropriately defined linear programming problem. Second, a highly convenient data classification algorithm can be used based on simple vector dominance reasoning. The algorithm, which we used in the empirical application to be discussed below, basically proceeds as follows. Each observation is sequentially compared to all other observations. An observation is declared inefficient if it is possible to find another observation which produces the same or more outputs with strictly less of at least one input, or which uses the same or less inputs to produce strictly more of at least one output. Observations for which no such other observation exists in the data set are 'undominated'. They

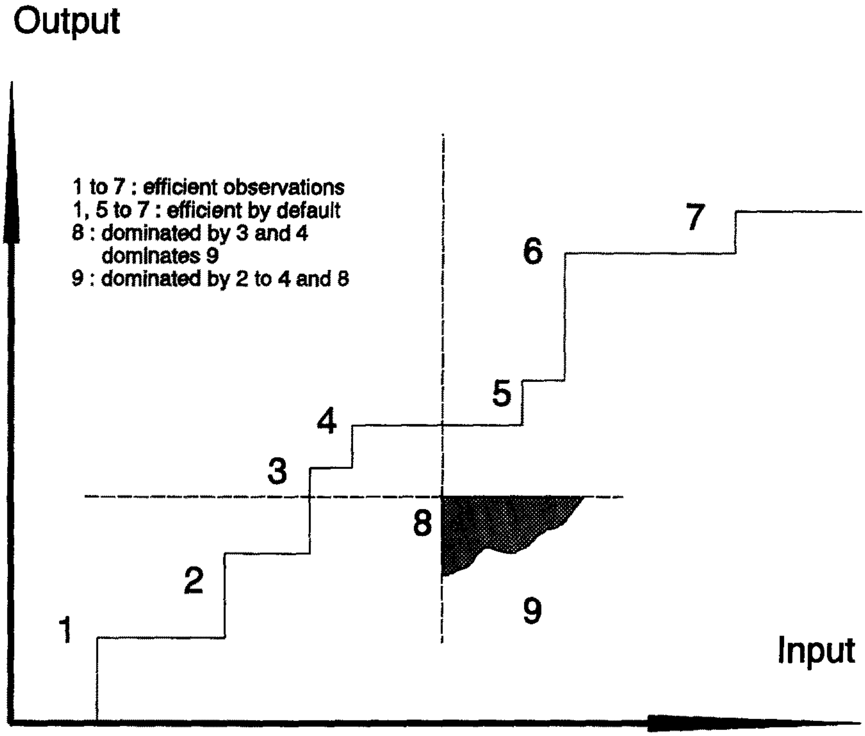

Figure 1. FDH graph reference technology.

are declared efficient. On the contrary, dominated observations are inefficient. Finally, observations which are efficient but which never dominate another observation are called 'efficient by default'. Due to the partial ordering implied in the vector dominance reasoning the method is unable to make precise statements concerning their technical efficiency.

The method is illustrated in Figure 1. Observations 1 to 7 are efficient. Furthermore observations 1 and observations 5 to 7 are efficient but do not dominate any other observation. They are efficient by default. Observation 8 is dominated by observations 3 and 4 and itself dominates observation 9. Note finally the effect of not imposing convexity. The FDH approach results in observation 5 being efficient. However, had convexity been imposed this observation would have been dominated by a linear combination of observations 4 and 6. It therefore would have been labeled inefficient.

It is important to emphasize that the minimal technical and behavioral assumptions and the close enveloping of observed production units make the FDH reference technology particularly useful for analyzing public sector efficiency questions. Indeed, there is no generally accepted model of local governmental behavior that would justify the imposition of strong behavioral assumptions. Moreover, as illustrated above, the efficiency indices based on the FDH reference technology are conservative compared to those obtained by methods assuming convexity. Use of a conservative approach may be considered an advantage in an analysis of the public sector, where technical inefficiencies may give rise to intense discussions on the political platform. An observation labeled inefficient relative to the FDH would certainly have been characterized as inefficient relative to any of the other commonly used reference technologies. A final advantage of the FDH is that, contrary to some of the other methods, inefficiencies are calculated *vis-à-vis* actually observed input-output combinations.

Of course, the advantages of the method have to be traded off against at least one obvious shortcoming, which is common to all non-parametric methods. The vector dominance reasoning implies a substantial sensitivity to the number of dimensions that are taken into account in the analysis. Increasing the number of inputs or outputs reduces the possibilities for an observation to be dominated, and therefore increases the probability of being declared efficient. We return to this feature of the FDH-method in the empirical section of the paper. Obviously, careful sensitivity analysis may throw some light on its empirical importance.

2.2. Definition of the efficiency measures

Having described the construction of the best practice frontier we now turn to the problem of defining indices of inefficiency that somehow measure the distance of inefficient observations to the frontier. In applied work based on the non-parametric approach it has been common to confine the attention to Farrell measures of either input or output inefficiency (see, e.g. Färe, Grosskopf and Logan, 1985: 89–106). For example, in the case only input inefficiency is considered one typically searches for the maximum scalarwise reduction of all inputs yielding the same output. In terms of the textbook isoquant analysis, input efficiency is measured along a ray through the origin (see Farrell, 1957: 253–290). Note that a Farrell-index of output inefficiency can be analogously defined by considering the maximal proportional increase in all outputs that is feasible for given inputs.

Although a case could be made in favour of non-radial efficiency measures, we limit our attention in this paper to indices of the Farrell type.[6] However, contrary to common practice in the literature, we do not restrict the analysis to separate input and output efficiency indices, but also calculate a graph efficiency index, taking into account all input and output dimensions simultaneously. This seems desirable, as restricting the indices to either the input or the output dimension implies that not all available information is used in the construction of the ranking of observations in terms of their productive efficiency. Therefore, in the empirical section of this paper we will report three Farrell efficiency indices referring to input, output, and graph efficiency, respectively. The latter is described in Färe, Grosskopf and Lovell (1985). It is obtained by simultaneously considering the maximum proportional reduction of all inputs and increases of all outputs.

The different efficiency indices are illustrated in Figure 2 for the case of one input and one output. Consider the inefficient observation 8. The corresponding input and output efficiency indices are given by the ratios ab/ac and ec/ed, respectively. The global efficiency index is slightly more subtle to interpret graphically. Applying the maximum common input reduction and output increase to observation 8 results in point 5′ on the FDH frontier. The global inefficiency index is then given by the ratio af/ac, which by definition equals the ratio ec/eg.

3. Technical efficiency in Belgian municipalities

In this section we apply the methodology previously outlined to study the efficiency of local public service provision by Belgian municipalities. Because of the quality of the data, we must admit at the outset that the analysis is limited in scope. Our data set included three potential input indicators and five potential output indicators for each of the 589 local governments in 1985.[7]

First consider our input proxies. As information on material inputs was totally unavailable we focused on the construction of indicators for labor and capital inputs. With respect to the former we had information on total municipal staff as well as on two separate categories of personnel, viz. the number of white collar and the number of blue collar workers. Using both components of the labor force as district inputs may be interpreted as an attempt to account for the implicit heterogeneity of the labor force.

With respect to capital it should be pointed out that the construction of a proxy variable was severely hampered by current accounting rules imposed on local governments in Belgium. These are heavily based on the cameralistic system, which is control- rather than management-oriented. Among others, it does not provide a direct evaluation of municipal assets. Consequently, a systematic registration of the capital stock is unavailable, and the information necessary to construct a satisfactory proxy is simply lacking. As a crude proxy for the services provided by the capital stock we therefore used the surface of buildings owned by the municipalities. We realize that this is a less than desirable proxy, but within the Belgian context no better indicate is currently available.

The outputs used represent important aspects of local production in the field of education, transportation, and social and recreational services. Specifically, the output indicators available in our data set were:

(i) the surface of municipal roads;
(ii) the number of beneficiaries of minimal subsistence grants;
(iii) the number of students enrolled in local primary schools;
(iv) the surface of public recreational facilities;[8]
(v) a proxy variable for the services delivered to non-residents. This variable, which can be thought of as a centrality index, was defined as the logarithm of the number of non-residents working in the municipality divided by the logarithm of total employment in the municipality.

Several remarks related to these indicators are in order. First, it is clear that for the majority of the outputs considered substantial differences in quality may exist. For example, roads can have a different surface quality, and production requirements may differ due to variations in topography. Such detailed information on the municipal road system is unfortunately not available. More importantly, however, the variables (ii) and (iii) are to some extent demand-determined. If inflexibilities exist with respect to quantities, municipalities may adjust quality instead. For example, if the number of students unexpectedly rises due to demand pressures, local schools may not have the possibility of increasing inputs in the educational process, in which case the result will simply be an automatic increase in average class size. Moreover, quality differences may naturally arise as a consequence of variations in stated preferences for local public services. Unfortunately, more detailed data on e.g. school quality and the average size of grants to beneficiaries are not recorded at the municipal level. This lack of qualitative information implies that the subsequent analysis should be cautiously interpreted.

Second, note that the inclusion of the fifth output (v) is intended to capture the idea of spill-over effects to other municipalities. One expects, *ceteris paribus*, more input resources to be necessary in case the services provided by e.g. the road system are being used intensively by non-residents.

As suggested in the previous section we applied the FDH-approach to calculate Farrell indices of input efficiency, output efficiency, and graph efficiency.[9] Moreover, to provide some information on the sensitivity of the method with respect to the number of dimensions taken into account in the analysis we report on three different applications. As a benchmark case, in a first application we treat total municipal staff as the only input in the production of the five outputs. In a second case we use two inputs, viz. total municipal staff and the proxy for capital services previously defined. Finally, a third application uses three separate inputs, viz. the number of blue collar workers, the number of white collar workers, and the proxy for capital.[10]

Table 1. Descriptive statistics of Farrell efficiency measures

	5 outputs / 1 input			5 outputs / 2 inputs			5 outputs / 3 inputs		
	Farrell			Farrell			Farrell		
	global	input	output	global	input	output	global	input	output
Mean	.974	.863	.969	.989	.948	.986	.994	.967	.991
Minimum	.724	.163	.724	.818	.303	.751	.863	.363	.766
Std Dev	.045	.199	.052	.028	.127	.034	.020	.097	.028
Kurtosis	8.847	3.588	7.141	12.442	9.038	13.241	19.305	14.377	22.365
Skewnes	−2.332	−1.295	−2.069	−3.020	−2.524	−3.055	−3.925	−3.318	−4.072
# Most dom. observations	85 (14%)	75 (13%)	83 (14%)	68 (11%)	61 (10%)	64 (11%)	51 (09%)	50 (08%)	53 (09%)
# Ineffic		261 (44%)			141 (24%)			104 (18%)	
# Efficient by default		107 (18%)			292 (50%)			371 (63%)	

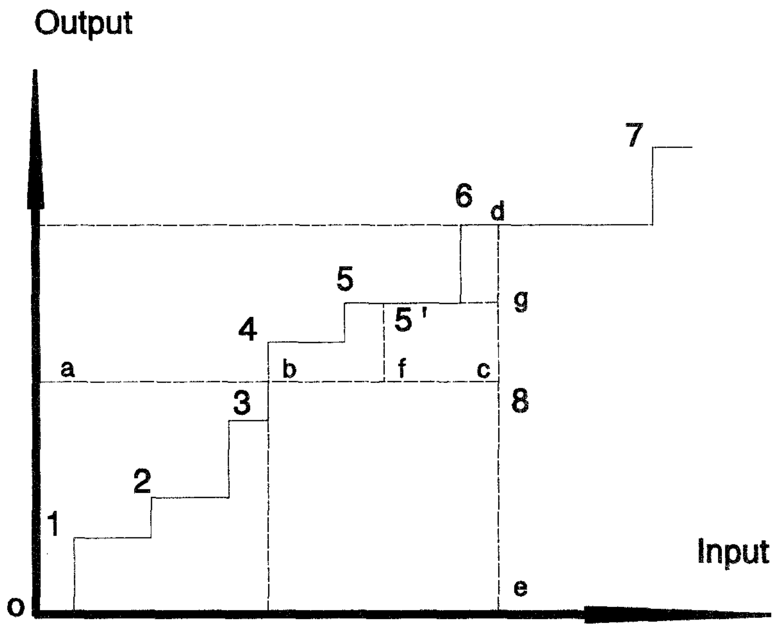

Figure 2. Farrell efficiency measures.

Summary results for the three cases considered are reported in Table 1. The results clearly illustrate the consequences of using a conservative reference technology, which is implied by use of the FDH-method. In the five output-one input case 56% of all municipalities is classified as efficient. Approximately 18% of the number of observations is declared efficient by default. As increasing the number of inputs in the data set decreases the possibility of being dominated by other observations, the analysis based on two and three inputs yields an even larger number of efficient municipalities. The results clearly illustrate the importance of the number of dimensions on which the efficiency measure is calculated. Both the mean efficiency scores and especially the number of observations that are declared 'efficient by default' increase with the number of dimensions, whereas the number of inefficient observations declines.

Two further observations are obvious from Table 1. First note that, as a consequence of the conservative nature of the FDH-method, the average efficiency scores are high. Second, it is not surprising to find that the alternative Farrell measures lead to substantial differences in calculated inefficiencies. In the initial analysis based on five outputs and one input mean input efficiency amounts to 0.863, indicating that, on average, municipalities could produce their observed output levels with approximately 14% fewer inputs. Mean output and global (graph) efficiency are calculated to be 0.969 and 0.974, respectively. The latter suggests that, on average, local governments could have produced 2.6%

Table 2. Correlations between Farrell efficiency measures

	5 outputs / 1 input			5 outputs / 2 inputs			5 outputs / 3 inputs		
	Farrell			Farrell			Farrell		
All observations	global	input	output	global	input	output	global	input	output
Farrell global	1.000			1.000			1.000		
Farrell input	.695	1.000		.760	1.000		.794	1.000	
Farrell output	.955	.655	1.000	.944	.710	1.000	.815	.653	1.000
	Farrell			Farrell			Farrell		
Inefficient observations	global	input	output	global	input	output	global	input	output
Farrell global	1.000			1.000			1.000		
Farrell input	.425	1.000		.472	1.000		.600	1.000	
Farrell output	.925	.304	1.000	.885	.340	1.000	.651	.267	1.000

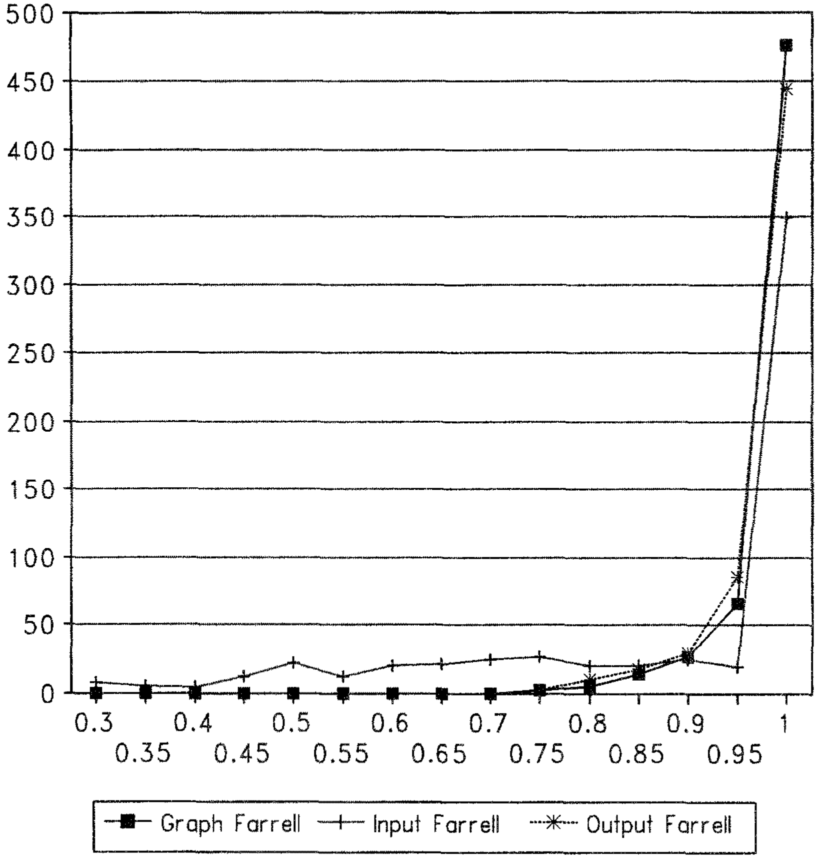

Figure 3. Histogram: Farrell efficiency measures (5 outputs / 1 input).

more output with 2.6% less input. Also note that the different measures have a quite different range and standard deviation. The input and output measures are substantially more dispersed. Finally, observe that quite similar remarks apply for the analysis based on two and three inputs.

The choice of dimensions not only affects the location and shape of the distribution, it also alters the implied rankings of technical efficiency. In Table 2 we compare the correlation coefficients between different efficiency measures. The correlation between the output and input measure is relatively small. For example, it amounts to 0.655 in the five outputs-one input case. However, if one calculates the correlation coefficients on the inefficient observations only this figure is as low as 0.304. The correlation between input and graph measures and between output and graph measures amounts to 0.425 and 0.925, respectively. The high correlation between output and graph measures is obviously due to the fact that outputs made up the majority of dimensions in the FDH-analysis.

To conclude this section, Figure 3 presents the distribution of the efficiency measures for the case of five outputs and one input. These distributions are obviously bimodal due to the concentration of efficient municipalities at unity. They are somewhat skewed to the right even if one ignores the efficient observations.

4. Explaining technical inefficiencies of Belgian municipalities

In this section we report on our attempt to explain differences in the calculated technical inefficiencies of Belgian municipalities. We consecutively present the estimation method, suggest a number of potential determinants of variations in efficiency, and discuss the empirical results.

However, before turning to a discussion of the estimation method and an analysis of the empirical results it is important to remember that in this paper the reconstruction of the frontier and the calculation of inefficiency indices has been separated from the explanation of inefficiencies. Although this is conceptually acceptable and quite common in the literature, the empirical implications of this procedure should be carefully understood. At the empirical level it may not be obvious to disentangle the determinants of the frontier from the determinants of inefficiencies. For example, there is ample evidence that the composition of the population may affect the cost of local public service provision.[11] Consequently, to some extent the characteristics of the local population may directly affect the efficiency frontier itself. Clearly, since the FDH-analysis does not take the composition of the local population into account into the construction of the frontier, variations in this variable will typically lead to different deviations from the calculated frontier.[12]

An appropriate model to explain efficiency differences as revealed by the FDH approach should take account of the characteristics of the distribution of the efficiency measure. Following Martin and Page (1983: 608–617) and Rhodes and Southwick (1989) we used the Tobit censored regression model to accommodate the mass of efficiency scores at unity. This seems warranted because the true variability in efficiency among the municipalities having an efficiency score equal to one is unobserved. Moreover, as indicated before, the FDH method implies that nothing can be said about the relative efficiency of those municipalities declared 'efficient by default'. Consistent with this observation, they were deleted from the sample in the explanatory analysis that follows.

For our purpose the standard Tobit model can be defined in the following way:

$$y_i^* = x_i'\beta + u_i,\ i=1,\ldots,n$$
$$y_i = y_i^* \quad \text{if } y_i^* < 1$$
$$y_i = 1 \quad \text{if } y_i^* \geq 1$$

where u_i are assumed to be i.i.d. drawings from $N(0,\sigma^2)$. The latent variable y^*_i is not directly observable. Its observed counterpart is the efficiency index y_i, which is censored at the limit level of 1, thus masking the true value of y^*_i. For y^*_i less than 1 both y_i and x_i are observed while for $y^*_i \geq 1$ the x_i are observed and the y_i equal the limit value of 1. It is well-known that the Tobit estimates are sensitive to any violation in the underlying assumptions.

Many studies dealing with estimating inefficiencies in the public sector simply do not attempt to explain the estimated differences in a systematic way (see, e.g., Levitt and Joyce, 1987). However, recently a number of exceptions have appeared in the literature (Bartel and Schneider, 1991; Boardman and Vining, 1989; Lovell, Walters and Wood, 1990; Silkman and Young, 1982). Although these studies did not measure efficiency using non-parametric techniques or were not specifically concerned with local governments, they do provide useful suggestions with respect to the potential determinants of inefficiency. Moreover, the literature on productivity growth in the local public sector and the public choice literature each provide additional determinants. Finally, our search for explanatory factors of municipal inefficiencies has been guided by our understanding of the Belgian institutional framework.

A first source of inefficiencies may be related to a poor adjustment of municipalities' size to the optimal scale of providing local public services (see, e.g., Spann, 1977: 71–89). For example, the size of the municipality may inhibit exploiting economies of scale in some or all of the production processes. To analyze the relation between scale and efficiency we included the municipality's population (POP) as explanatory variable.[13]

Second, when appropriately applied to the public sector both the theory of property rights and, more recently, principal-agent models suggest the possibility that politicians and public managers may pursue goals independent from the constituency they represent and from the organization in which they operate. A number of reasons have been suggested as to why they may lack appropriate incentives to effectively audit and control expenditures. The public choice literature suggests that the process of political decisionmaking itself may impede the effective control of the public sector (Mueller, 1989; Borcherding, Pommerehne and Schneider, 1982: 127–156; Bartel and Schneider, 1991: 17–40). Politicians' emphasis on political rather than economic rationality is likely to contribute to inefficiency. For example, top bureaucrats may be appointed according to party affiliation and not because of their managerial skills. In addition, political rationality may imply the use of explicit or implicit (e.g. logrolling) 'side payments' in the decision-making process. In this respect, the size of political coalitions may affect technical inefficiency because arbitrage in the bargaining process may require more such payments. To approximate the above ideas, two sets of variables were constructed. First, we introduced the number of parties in a municipal coalition (CPAR). Second, although there is a priori no compelling theoretical argument to expect one party to be more technically efficient than another, variables capturing the composition of national and local governments have been found to explain not only the structure but also the absolute size of government spending in Belgium (De Grauwe (1985)). To test whether inefficiencies themselves might be party-related we used dummy variables indicating the presence of a particular political family in the ruling coalition (CLIB and CSOC for the liberal and socialist parties, respectively).[14]

It is conceivable that the incomes and wealth of citizens affect the incentives of both politicians and taxpayers to effectively control expenditures. First, these factors largely determine the fiscal capacity of municipalities. Higher fiscal revenue capacity may increase the on-the-job leisure of politicians and public managers and affect the possibilities to operate inefficiently. Second, citizens of high-income municipalities may be less motivated to effectively monitor expenditures, for example due to the higher time cost involved. To proxy for the above influences we included average personal income (INCOME) as an explanatory variabie.[15]

The financing of local public services may be important for several reasons. First, it has been argued (see, e.g., Spann, 1977: 71–89) that high tax prices associated with a given level of service provision increases voters' monitoring of public expenditures, especially if cost comparisons between municipalities are easy. We therefore investigated to what extent high local tax rates encourage efficiency. In Belgium the two main municipal taxes are a local income tax and the property tax. Both tax rates were experimented with. Second, on average, slightly more than 20% of local government operations are funded by block grants. These are often believed to induce a 'flypaper' effect in that they result in a larger increase in local government expenditures than an equivalent change in residential incomes (see, e.g., Hamilton, 1983: 347–361). Although this is not implied by the flypaper effect, it could in addition be hypothesized that large grants increase the potential for technical inefficiency. Some evidence for this phenomenon has indeed been found for the US (see, e.g., Silkman and Young, 1982). In the regressions we therefore added the size of the block grant (GRANT) as an explanatory variable.

Finally, the performance of a municipality may be enhanced by the political participation of its citizens. Although it is difficult to directly quantify political participation, there is some evidence in the literature that the latter is related to education. For example, in the US one typically finds that voting is strongly affected by education (see Mueller, 1989: 121–122). Although in Belgium voting is mandatory so that no comparable evidence is available, it is nevertheless interesting to see whether the potential relation between education and political participation has an identifiable effect on local government inefficiencies. We therefore included the share of the adult population holding a degree of higher education as an explanatory variable (HEDUCAT).

Note that we do not claim that this list of potential explanatory variables is complete. As in most empirical work some variables could not be explored due to data limitations. For example, it has been argued that the degree of unionization of municipal personnel, the possibility to obtain certain publicly provided goods from private suppliers, and the opportunity to contract out services may increase technical efficiency (see Spann, 1977: 71–89; Bartel and Schneider, 1991: 17–40; Boardman and Vining, 1989: 1–33). Moreover, several models explain the public sector's tendency towards an excessively large bureaucracy encouraging technical inefficiency (see, e.g., Niskanen, 1974). Unfortunately, we did not have any information concerning these potential determinants, except for some poor proxy variables, and therefore could not assess their explanatory power.[16]

A number of Tobit models were estimated by maximum likelihood techniques. In order to save space, we only report the results of the explanatory analysis based on the global (graph) efficiency measure. Moreover, we only give a relatively small subset of alternative specifications.

Estimated coefficients are reported in Table 3.[17] The scale variable (POP) has a significant positive effect, indicating that the larger municipalities operate more efficiently in terms of the calculated FDH-indices. This may suggest that for the smaller municipalities, despite the giant fusion operation of Belgian municipalities in the seventies, the scale of public good provision may still be suboptimal.[18] The income variable (INCOME) yields a negative coefficient, consistent with the interpretation of this variable as affecting both politicians' and taxpayers' incentives to monitor local expenditures. Note, however, that the estimated coefficients are not always significantly different from zero.

The results further point at the negative impact of the number of coalition partners (CPAR). As the corresponding coefficients are not significant this finding only yields some weak support for the hypothesis formulated above. Replacing the number of coalition partners by dummy variables indicating the presence of a political family in the coalition suggest that the presence of the liberals (CLIB) tends to decrease technical efficiency, while the presence of the socialist party (CSOC) does not seem to have a significant effect.

The block grant variable (GRANT) consistently yields a negative coefficient. With one exception, it is significantly different from zero. Interpreting this result literally suggests that grants may not only encourage local service provision, but that they also lead to some additional technical inefficiency. Interestingly, note that the two local tax rates that we experimented with failed to

Table 3. Determinants of technical efficiency: Tobit results (standard errors between brackets)

	5 outputs/1 input		5 outputs/2 inputs		5 outputs/3 inputs	
INTERCEPT	.972	.970	.988	.983	1.134	1.119
	(.033)*	(.032)*	(.041)*	(.039)*	(.050)*	(.048)*
POP	.54E-02	.55E-02	.41E-02	.39E-02	.291E-02	.28E-02
	(.95E-03)*	(.93E-03)*	(.12E-02)*	(.12E-02)*	(.16E-02)*	(.15E-02)*
INCOME	−.18E-03	−.21E-03	−.32E-04	−.24E-04	−.99E-03	−.99E-03
	(.24E-03)	(.24E-03)	(.29E-03)	(.29E-03)	(.36E-03)*	(.35E-03)*
GRANT	−.56E-03	−.57E-03	−.47E-03	−.44E-03	−.45E-03	−.50E-03
	(.12E-03)*	(.12E-03)*	(.18E-03)*	(.18E-03)*	(.30E-03)	(.30E-03)*
CPAR	−.38E-02		−.47E-02		−.011	
	(.59E-02)		(.69E-02)		(.78E-02)	
CLIB		−.019		−.015		−.031
		(.89E-02)*		(.010)		(.011)*
CSOC		.36E-02		−.19E-02		.010
		(.79E-02)		(.91E-02)		(.010)
HEDUCAT	.20E-02	.23E-02	.71E-03	−.72E-03	.51E-02	.55E-02
	(.12E-02)*	(.12E-02)*	(.14E-02)	(.14E-02)	(.17E-02)*	(.17E-02)*
Ln L	146.75	148.86	72.963	73.963	38.834	41.998

* Significance at the 90% confidence level.

produce significant estimates; they were not included in the final specifications reported in Table 3. The estimated negative impact of block grants combined with the consistent insignificance of the local tax rates may point at the presence of some fiscal illusion.

Finally, the educational variable (HEDUCAT) seems to confirm the hypothesis that education enhances efficiency. As previously explained, a possible interpretation of this finding is that education has an effect on political participation and control, and hence increases the pressure on the local authorities to operate more efficiently.

Not surprisingly, note that for some variables the analyses based on one, two and three inputs lead to quantitatively large differences in coefficients. As previously indicated, both the number of inefficient observations and the number of municipalities labeled efficient by default are markedly different in each of the three cases. Qualitatively, however, the Tobit estimates are remarkably similar. In general, most of the signs and significance levels of the estimated coefficients are robust.

To conclude this section, one final fremark is in order. Our results were obtained in a single equation context, which implicitly assumes exogeneity of all independent variables.[19] This may not be entirely appropriate. For example, local tax rates and even the grants allocated to individual municipalities may be dynamically related to inefficiencies. It could be argued that a more thorough explanation of the degree of technical inefficiency requires a simultaneous modelling of all decision variables of the municipal authorities. Such a comprehensive analysis was outside the scope of this paper, however.

5. Conclusion

The purpose of this paper was twofold. First, based on the free disposal hull (FDH) reference technology we calculated various measures of productive efficiency for a data set of all 589 Belgian local governments. Second, within the framework of a censored regression model we attempted to explain in a systematic way the resulting distribution of the efficiency measures.

The FDH methodology was indicated to make minimal assumptions with respect to the production technology and to be relatively easy to implement. It was used to calculate input, output and global Farrell measures of productive efficiency. Mean technical efficiency of Belgian municipalities was found to range between 0.86 to more than 0.95, depending on the specification of outputs and the particular efficiency measure used. Given the relatively low correlation between the input and output efficiency indices we argued in favor of the Farrell graph measure.

Variations in efficiency among local governments were explained in terms of the structural and political characteristics of municipalities, taking into account the institutional environment in which they operate. Some evidence was found that the scale and the fiscal revenue capacity of municipalities are important determinants of efficiency. Moreover, the financing mechanism of local public service provision and the political characteristics of municipal governments were estimated to affect inefficiencies.

When judging the empirical results obtained in this paper, it is useful to keep in mind that the combination of a Farrell graph efficiency measure with the FDH reference technology may make the explanation of technical efficiency a difficult exercise. As noted earlier the FDH reference technology automatically yields conservative efficiency measures. Moreover, the Farrell graph measure results in a relatively limited range over the sample. Although this problem can easily be remedied by working with other technical efficiency measures, in this paper we did not want to depart from the tradition of using radial measures.

Notes

1. These studies include Deller, 1992 and Hayes and Chang, 1990.
2. See e.g. Pestieau and Tulkens, 1990.
3. For an early survey, see Førsund, Lovell and Schmidt, 1980: 5–25.

4. For a recent review of these reference technologies, see Seiford and Thrall, 1990: 7–38.
5. For details and interpretation we refer to Färe, Grosskopf, and Lovell, 1985: 24–25.
6. A number of non-radial measures have been proposed in the theoretical literature. For a detailed discussion, see Färe, Grosskopf and Lovell, 1985; Russell, 1988: 207–217 and Zieschang, 1984: 387–396.
7. Vanden Eeckaut, Tulkens and Jamar, 1991 have also reported results for the Belgian local authorities using FDH. This paper differs from their study in several respects. Firstly, their sample is restricted to the Walloon region. Secondly, their analysis is based on a comparison of costs and outputs. Thirdly, they use slightly different output indicators. Finally, they do not explain the variability in the calculated efficiency measures.
8. This includes the municipalities' surface of parks, and of sports and various other recreational facilities.
9. To perform the calculations an algorithm was written in Turbo-Pascal. Apart from Farrell efficiency indices the program also provides a wealth of additional information (the set of dominating observations, the excess in inputs and shortage in outputs, non-radial efficiency measures, etc.).
10. A much more complete sensitivity analysis was carried out to investigate the sensitivity of the results with respect to sample size, definition of inputs and outputs, and the number of input and output indicators used (see De Borger *et al.*, 1992). Moreover, an appendix to the present paper, containing additional applications of the FDH-method to alternative combinations of inputs and outputs, is available from the authors on request.
11. Recently, the normative implications of this finding have been investigated by Schwab and Oates, 1991.
12. For a detailed discussion of the differences between one-step and two-step procedure to estimate inefficiency, see Lovell, 1992.
13. As pointed out by a referee, the lack of quality-related information (e.g., with respect to the crowdedness of local public facilities) implies that the impact of population may well reflect agglomeration cost rather than inefficiency. To investigate this issue we also considered an FDH-analysis where some inputs and outputs were appropriately scaled by population. The results are described in an unpublished appendix available from the authors on request. Although efficiency scores turn out to be reasonably robust, the explanatory analysis does suggest the need for detailed qualitative information in order to more clearly separate congestion of public facilities from pure technical inefficiency.
14. A referee pointed out that the period of time a party has been in power might be an additional determinant of inefficiency, in the sense that increasing experience of politicians and bureaucrats may lead to increasing ability in exploiting the system to their own advantage. Unfortunately, this information was not available.
15. As an alternative to this income variable, a direct measure of fiscal revenue capacity was defined as the tax revenues generated by levying a 1% tax rate on the existing tax base. This yielded qualitatively similar results.
16. In a previous version of this paper we also allowed for the possibility of regional differences in efficiency by introducing dummy variables for the Walloon and the Brussels region. We simply interpreted these variables as reflecting regional effects of socio-economic and political characteristics not captured by the other variables. However, given our inability to provide a more detailed interpretation of the estimated effects and the heated political discussions on regional issues in Belgium, they were deleted from our final specifications.
17. Note that the estimated coefficients cannot directly be interpreted as partial effects. The appropriate correction factor is discussed in McDonald and Moffitt, 1980: 318–321 and Pudney, 1989. As an example the first regression in the five output case implies that a population increase of 10000 people results in an increase in efficiency with 0.19.

18. Note that this conclusion does not apply to the largest municipalities such as Brussels, Antwerp and Ghent. Several of those cities turned out to be efficient by default in the FDH-analysis. As previously explained, they were excluded in the explanatory analysis. The empirical results with respect to population should not be extrapolated far beyond the population range in the sample.
19. For each Tobit model estimated we applied the specification test suggested by Ruud (1984) to see whether the null hypothesis of no misspecification could be rejected. The results were mixed. At usual significance levels and depending on the exact specification used the hypothesis could in some cases marginally be rejected, while in other cases it could not.

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