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Evaluating Technical Efficiency of Italian Major Municipalities: a Data Envelopment Analysis model

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Abstract

This paper presents findings of an exploratory study aimed at assessing expenditure efficiency of 103 Italian major municipalities. The study implements Data Envelopment Analysis to calculate an efficiency score and investigate economies of scale. Findings reveal that there exist scale inefficiencies in a number of municipalities that need an in depth investigation.

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1. Introduction

In the past few decades, all over the world two major trends have characterized the effort of the central governments in search of a greater administrative efficiency: a) the merging of local municipalities, in the belief that the aggregation of small administrative entities would lead to expenditure reduction and efficiency gains due to scale economies (Fox & Gurley, 2006); b) a growing decentralization of administrative power, fiscal and administrative responsibilities from the central to the local government level, in order to increase efficiency by specializing public expenditure and better meeting needs of the territory, and even stimulating competition between municipalities in the allocation of funds from the central government. However, the outcome of this process has been many times either ambiguous or unknown due to a scarce attention for the evaluation of its effects. Measuring efficiency of local governments has become recently a major topic of debate both for practitioners and policy makers in search for performance benchmarks necessary to design targets defining accountability measures useful for decision-making at higher level of government, and for citizens and scholars more interested in understanding causes of public spending increase and determinants of scarce efficiency. More recently, in Italy the dramatic need to reduce the amount of public expenditure at all government levels has made the concern for measuring efficiency of local governments even more pressing. This paper presents findings of an exploratory study aimed at assessing expenditure efficiency of 103 Italian major municipalities. The study implements Data Envelopment Analysis (DEA) to calculate an efficiency score and investigate economies of scale.

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2. Literature

Research on efficiency of municipalities and local government services provision may be grouped into two main streams. The first stream includes studies that focus on the assessment of efficiency of single services delivered by municipalities, i.e. solid waste and sewage disposal (Worthington & Dollery, 2001), water management (Byrnes et al., 2010; Gupta et al., 2012; Picazo et al., 2009), urban public transportation (Boame, 2004; Fazioli et al., 1993; García Sánchez, 2009a; Walter & Cullmann, 2008), local police force (Carrington et al., 1997; García-Sánchez, 2009b), public health services (Nakayama, 2004). The second stream includes studies that are aimed at assessing an overall municipal efficiency score. In this stream, scholars have conducted a number of empirical investigations that cover several countries, i.e. Australia (Dollery et al., 2008; Worthington & Dollery 2008), Belgium (Geyes & Moesen, 2009a; De Borger and Kerstens, 1996; De Borger et al., 1994), Brazil (Sampaio de Sousa & Stošić, 2005; Sampaio de Sousa et al., 2005), Germany (Kalb, 2010a; Kalb et al., 2012), Finland (Loikkanen & Sisiluoto, 2005), Greece (Athanassopoulos & Triantis, 1998), Italy (Boetti et al., 2009; Giordano & Tommasino, 2011), Japan (Nijkamp & Suzuki, 2009), Portugal (Afonso & Fernandes, 2006 & 2008), Spain (Balaguer-Coll & Prior-Jimenez, 2009; Benito et al., 2008), Turkey (Kutlar et al., 2012).

In general, scholars are mostly interested in understanding what are the determinants of municipal efficiency. They have investigated the impact of a number of factors, such as (Balaguer-Coll et al., 2002; Byrnes, Dollery, 2002; Kalb, 2010b) availability of financial grants, environmental issues that are not under decision-makers' control, the lack/availability of managerial capabilities, size, economies of scope, economies of scale, etc. In particular, economies of scale might be an important factor to take into account to explain different rates of efficiency. However, results of the empirical studies are mixed and questions such as whether there are scale effects that support higher efficiency rates are far from being answered.

3. Method and sample

Both parametric and non-parametric techniques are generally used to assess unit efficiency in the public sector (Geys & Moesen, 2009b). The non-parametric approach that uses Data Envelopment Analysis (DEA) has several advantages. DEA is a deterministic mathematical programming technique that extends the Farrell's efficiency measure to a multiple outputs, multiple inputs setting, and adopts very weak assumptions related to the estimation of the empirical production function converting inputs into outputs for each municipality. Indeed, this technique relies only on simple assumptions such as the convexity and strong free disposability in inputs and outputs. The production frontier is generated solving a sequence of linear programming problems, one for each municipality included in the sample, while the relative technical efficiency rate (TE) of the municipality is measured by the distance between the actual observation and the frontier obtained from all the municipalities under examination. A municipality is efficient if TE=1, but if TE<1 a municipality is considered technically not efficient. Given the sample of municipalities, the model determines for each municipality the optimal set of input weights and output weights that maximize its efficiency score. DEA models can be either input or output oriented. In the study an input orientation is adopted and the production function is constructed by searching for the maximum possible proportional reduction in input usage, while output levels are held fixed. This choice is common in this kind of studies, because usually public expenditure is used as an input. As the sample includes municipalities having different size, efficiency was calculated adopting the conceptualization suggested by Banker, Charnes and Cooper (1984), thus assuming variable returns to scale (VRS) (BCC model). An input-oriented BCC LP model is defined as:

$$\min_{\Theta\lambda} \Theta$$

$$\text{subject to} \quad \begin{aligned} & -y_i + Y\lambda \geq 0 \\ & \Theta x_i - X\lambda \geq 0 \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned}$$

where Y denotes a matrix of output measures, X a matrix of input measures, $1'\lambda=1$ is the convexity constraint added to the CCR model (Charnes, Cooper, & Rhodes, 1978) that assumes constant returns to scale (CRS). The total technical efficiency (TE_{CRS}) can be decomposed into pure technical efficiency (TE_{VRS}) and scale efficiency (SE_a), where $SE_a = \frac{TE_{CRS}}{TE_{VRS}}$ (Coelli, Rao, & Battese, 1998). To find out whether a municipality is scale efficient and qualify the type of returns of scale, a DEA model under the non-increasing returns to scale (NIRS) is implemented by replacing the $N1'\lambda = 1$ restriction with $N1'\lambda \leq 1$, putting $SE_b = \frac{TE_{CRS}}{TE_{NIRS}}$, and the following rule can be applied (Fare, Grosskopf, & Lovell, 1985) if SE_a=1, then a municipality is scale efficient, both under CRS and VRS; if SE_b=1 it operates under increasing returns to scale; if SE_b<1, it operates under decreasing returns to scale.

As usual in studies like this, the choice of the input and output variables followed the criteria of relevance and data availability. Inputs include annual expenditures relative to: urban waste management, public transportation, general consumptions (i.e., phone, electricity, gas, water), leases and rentals, cleaning services, cars and property maintenance, communications and representation, miscellaneous (stationery, consumables, and supplies), advise and consulting services. Data relate to fiscal year 2011, while source is the SIOPE, the database of the Italian Ministry of Economics. Outputs include: urban infrastructure development, urban ecosystem quality, nursery schools, municipality area extension, and resident population. Sources of data are: Istituto Tagliacarne, Legambiente, Sole24ore, ISTAT (the last two variables). Sample is made of 103 large municipalities, 46 in Northern, 22 in Central, and 35 in Southern Italy. Average population is 170,057, while average area extension is 179.58 sq. km.

4. Empirical analysis

Table 1 displays the outcome of DEA. Average CCR and BCC efficiency scores are 85.34% and 88.13%, which are rather high rates for studies on this subject. Minimum efficiency scores are 37.52% and 37.65% for the CCR and BCC models, respectively. The number of 100% efficient municipalities in the CCR and BCC models is 60 and 66, i.e. 58% and 64% of sample. The BCC (in)efficiency score of 32 municipalities remains below sample average.

The findings reveal a production technology with variables returns to scale. Forty-three municipalities are scale inefficient; in particular, 34 have decreasing returns to scale, while 9 have increasing returns to scale. These findings apparently support the idea that there might be important scale inefficiencies that make public expenditure of municipalities scarcely efficient. But, unexpectedly inefficiencies are mostly due to decreasing returns rather than increasing returns to scale. As the average population size of the group of municipalities having increasing returns to scale is smaller than that of the group having decreasing returns to scale (93,961 vs 97,889), the influence of scale on the efficiency rate might be very likely. However, data relative to average population size and area extension of municipalities having constant returns to scale reveal that things are more complex and a more in depth investigation about determinants of inefficiency is necessary. The population size and area extension of the average municipality in this latter group are indeed 222,365 inhabitants and 211.27 sq. km.

The findings of this analysis stimulate further meditation about two major issues: a) merging to benefit from scale economies may not be the only alternative for the municipalities. Both small and large municipalities may increase their operational and financial efficiency by contracting out the provision of some of their services to private companies, public or private-public municipal companies, or even other local government entities. Smaller municipalities may also establish a formal association to share the provision of public services, keeping themselves legally independent. That is the case, for instance, of transportation, water and sewerage management services; b) factors such as the environment uncontrollable variables, the decision-making process complexity, and the managerial capability might be more important than size to explain greater efficiency of larger municipalities.

In this study, inefficiencies due to measurement errors, omitted variables, the presence of outliers, and other statistical discrepancies were not taken into account.

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Table 1. DEA efficiency scores

Code	Municipality	CCR	BCC	NIRS	SE_a	RtS	Code	Municipality	CCR	BCC	NIRS	SE_a	RtS
M1	Agrigento	100.00	100.00	100.00	1.000	crs	M53	Messina	100.00	100.00	100.00	1.000	crs
M2	Alessandria	100.00	100.00	100.00	1.000	crs	M54	Milano	100.00	100.00	100.00	1.000	crs
M3	Ancona	64.03	68.63	68.63	0.933	drs	M55	Modena	100.00	100.00	100.00	1.000	crs
M4	Aosta	59.51	92.46	92.46	0.644	drs	M56	Napoli	100.00	100.00	100.00	1.000	crs
M5	Arezzo	100.00	100.00	100.00	1.000	crs	M57	Novara	74.24	84.87	84.87	0.875	drs
M6	Ascoli P.	100.00	100.00	100.00	1.000	crs	M58	Nuoro	100.00	100.00	100.00	1.000	crs
M7	Asti	100.00	100.00	100.00	1.000	crs	M59	Oristano	55.83	56.66	56.66	0.985	drs
M8	Avellino	100.00	100.00	100.00	1.000	crs	M60	Padova	65.77	70.63	70.63	0.931	drs
M9	Bari	52.41	54.60	54.60	0.960	drs	M61	Palermo	100.00	100.00	100.00	1.000	crs
M10	Belluno	92.84	100.00	100.00	0.928	drs	M62	Parma	100.00	100.00	100.00	1.000	crs
M11	Benevento	65.35	70.34	65.35	0.929	irs	M63	Pavia	53.76	57.38	57.38	0.937	drs
M12	Bergamo	47.70	47.91	47.70	0.996	irs	M64	Perugia	100.00	100.00	100.00	1.000	crs
M13	Biella	81.77	88.02	88.02	0.929	drs	M65	Pesaro	100.00	100.00	100.00	1.000	crs
M14	Bologna	100.00	100.00	100.00	1.000	crs	M66	Pescara	100.00	100.00	100.00	1.000	crs
M15	Bolzano	100.00	100.00	100.00	1.000	crs	M67	Piacenza	100.00	100.00	100.00	1.000	crs
M16	Brescia	38.87	39.52	38.87	0.984	irs	M68	Pisa	100.00	100.00	100.00	1.000	crs
M17	Brindisi	77.19	100.00	100.00	0.772	drs	M69	Pistoia	100.00	100.00	100.00	1.000	crs
M18	Cagliari	37.52	37.65	37.52	0.997	irs	M70	Pordenone	39.46	62.83	62.83	0.628	drs
M19	Caltanissetta	100.00	100.00	100.00	1.000	crs	M71	Potenza	100.00	100.00	100.00	1.000	crs
M20	Campobasso	100.00	100.00	100.00	1.000	crs	M72	Prato	100.00	100.00	100.00	1.000	crs
M21	Caserta	100.00	100.00	100.00	1.000	crs	M73	Ragusa	100.00	100.00	100.00	1.000	crs
M22	Catania	95.99	96.89	96.89	0.991	drs	M74	Ravenna	100.00	100.00	100.00	1.000	crs
M23	Catanzaro	51.02	54.24	54.24	0.940	drs	M75	Reggio C.	100.00	100.00	100.00	1.000	crs
M24	Chieti	58.83	59.61	59.61	0.987	drs	M76	Reggio E.	100.00	100.00	100.00	1.000	crs
M25	Como	71.99	78.27	78.27	0.920	drs	M77	Rieti	61.65	62.87	61.65	0.981	irs
M26	Cosenza	100.00	100.00	100.00	1.000	crs	M78	Rimini	100.00	100.00	100.00	1.000	crs
M27	Cremona	100.00	100.00	100.00	1.000	crs	M79	Roma	100.00	100.00	100.00	1.000	crs
M28	Crotone	39.01	54.85	39.01	0.711	irs	M80	Rovigo	100.00	100.00	100.00	1.000	crs
M29	Cuneo	59.99	62.85	62.85	0.954	drs	M81	Salerno	98.13	100.00	100.00	0.981	drs
M30	Enna	46.61	46.94	46.94	0.993	drs	M82	Sassari	100.00	100.00	100.00	1.000	crs
M31	Ferrara	100.00	100.00	100.00	1.000	crs	M83	Savona	88.52	100.00	100.00	0.885	drs
M32	Firenze	100.00	100.00	100.00	1.000	crs	M84	Siena	100.00	100.00	100.00	1.000	crs
M33	Foggia	100.00	100.00	100.00	1.000	crs	M85	Siracusa	80.22	82.78	82.78	0.969	drs
M34	Forlì	86.96	88.33	86.95	0.984	irs	M86	Sondrio	49.97	50.00	49.97	0.999	irs
M35	Frosinone	100.00	100.00	100.00	1.000	crs	M87	Taranto	89.42	100.00	100.00	0.894	drs
M36	Genova	100.00	100.00	100.00	1.000	crs	M88	Teramo	100.00	100.00	100.00	1.000	crs
M37	Gorizia	100.00	100.00	100.00	1.000	crs	M89	Terni	100.00	100.00	100.00	1.000	crs
M38	Grosseto	78.34	86.51	86.51	0.906	drs	M90	Torino	100.00	100.00	100.00	1.000	crs
M39	Imperia	69.35	69.60	69.60	0.996	drs	M91	Trapani	100.00	100.00	100.00	1.000	crs
M40	Isernia	68.19	89.76	68.20	0.760	drs	M92	Trento	59.54	100.00	100.00	0.593	drs
M41	La Spezia	100.00	100.00	100.00	1.000	crs	M93	Treviso	100.00	100.00	100.00	1.000	crs
M42	L'Aquila	100.00	100.00	100.00	1.000	crs	M94	Trieste	100.00	100.00	100.00	1.000	crs
M43	Latina	60.90	64.44	64.44	0.945	drs	M95	Udine	45.64	46.23	46.23	0.987	drs
M44	Lecce	66.18	69.86	69.86	0.947	drs	M96	Varese	100.00	100.00	100.00	1.000	crs
M45	Lecco	71.07	71.59	71.59	0.993	drs	M97	Venezia	100.00	100.00	100.00	1.000	crs
M46	Livorno	100.00	100.00	100.00	1.000	crs	M98	Verbania	100.00	100.00	100.00	1.000	crs
M47	Lodi	47.17	49.34	49.34	0.956	drs	M99	Vercelli	100.00	100.00	100.00	1.000	crs
M48	Lucca	100.00	100.00	100.00	1.000	crs	M100	Verona	57.67	64.15	64.15	0.899	drs
M49	Macerata	67.09	67.17	67.17	0.999	drs	M101	Vibo V.	100.00	100.00	100.00	1.000	crs
M50	Mantova	77.00	87.95	87.95	0.833	drs	M102	Vicenza	100.00	100.00	100.00	1.000	crs
M51	Massa	83.59	83.96	83.96	0.995	drs	M103	Viterbo	57.81	57.83	57.81	1.000	irs
M52	Matera	100.00	100.00	100.00	1.000	crs							
crs=constant returns to scale, irs=increasing, drs=decreasing, RtS=returns to scale								mean	85.34	88.13	87.68		
								st.dev	20.28	18.52	19.05		
								minimum	37.52	37.65	37.52		