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The efficiency of the municipal waste management model in the Italian Municipalities

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In recent years, the role played by Public Administration in producing local public services has changed dramatically. This is due partly to the increasing burden of complex necessities in the sector, as well as to the progressive evolution of society (Andrews and Entwisle, 2014). As a result, the government is now responsible for providing fundamental services in the lives of all individual citizens (Spallini, 2014). Unfortunately, notwithstanding the increase in demand, given the current ongoing recession, the public services sector suffers from a lack of financial resources. In order to resolve this conflict, the PA must adopt the strategy of increasing the efficiency of producing public services, while at the same time reducing and streamlining costs. To do this, the production of public services must be rationalized by adopting more efficient management models (Andrews and Entwisle, 2014).

The aim of this paper is to analyse the efficiency of management in the municipal waste service in Italian cities and to find and examine the connection between the levels of efficiency and the management model adopted by each city. This study uses Data Envelopment Analysis to calculate a score for efficiency and to investigate the economies of scale in reference to the management models used. As a primary result, we have identified a positive relationship between dimension and efficiency, given that we discovered more efficient management models with public capital or mixed public-private rather than those operating with only private equity capital.

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keywords: Efficiency analysis, DEA, public services, waste management.

1 Introduction

In the last decade, numerous laws have created new opportunities for local governments in organizing the management of local public services, mainly in order to adapt national legislation to European legislative requirements.

First of all, it is necessary to clarify the concept of what is considered local public service, which is somewhat controversial by definition.

In Italian law, the only source defining local public service is article 112 TUEL: "*The production of goods and activities directed to achieve social purposes and to promote economic and civil development of local communities*".

When the public services in question can be managed in an entrepreneurial way, they are defined as public services of economic importance, specifically, as SIEG - economic service of general interest as defined by TFUE in art. 14 and 106 and in art. 36 Charter of Fundamental Rights in the European Union.

The services provided by the local authority to its community: SPL economically significant (SIEG in UE); SPL without economic significance (SINEG in UE); Instrumental services (are the services provided to the local authority, to which citizens benefit only indirectly) (Fassman et al., 2015).

Key local public services of economic importance are: the distribution of electricity, the distribution of natural gas, integrated water services, the management of municipal waste, and local public transport.

The evolution of the field of local public services follows the trends of the international movement of New Public Management, which aims to ensure greater efficiency of public administrations in meeting the needs of citizens according to the logic of efficiency, functionality and accountability (McLaughlin et al., 2002; Behn, 1998; Boyne, 2002; Boyne et al., 2004; Hood, 1995; Pollitt, 1986).

According to Italian law (Constitutional Court judgment 199/2012) and EU regulations, there are several Governance models for the production of economically significant SPL (Barisano, 2012; Galetta, 2007).

A. Entrepreneur or public company dealers, with private equity.

B. Public company as a joint venture, with government and private equity.

C. In-house providing, a government-owned corporation, with public equity.

The local government authorities are free to choose what they consider the best management model, taking into account:

- The European principles of competition, freedom of establishment and freedom to provide services.
- The principles of efficiency, effectiveness and economy of government action.

In fact, when they choose to operate the service with an in-house company, as apposed to an external provider, they are required to justify that choice by entering the motivation in a report to be published on the institutional website (art. 34, par. 20, del D.L. 179/2012).

Furthermore, the Italian Government has begun a process of local public service reforms in order to achieve full efficiency through the following steps:

Exceeding the fragmentation in the organization and management services (Centioli, 2014).

According to the art. 3-bis of D.Lgs. 138/2011, regions and autonomous provinces must:

- Delimit the territorial area of optimum size (in Italian ATO: Ambiti territoriali ottimali), which has to be at least as large as provincial areas.
- Justify smaller dimensions in accordance with proportionality, adequacy and efficiency principles and territorial and socio-economic differentiation criteria.

2 Literature review

In literature, there are various ways of determining the efficiency of public expenditures. Some authors apply composite indicators (Afonso and St. Aubyn, 2005; Afonso et al., 2010; Geys and Moesen, 2009), others apply non parametric methods (e.g., data envelopment analysis [DEA]) in order to obtain efficiency scores (Afonso and St. Aubyn, 2005; Afonso et al., 2005, 2010) a third way is to employ stochastic frontier analysis (Adam et al., 2011).

There are numerous previous models utilizing DEA to analyse the efficiency of municipalities in the waste sector (Rogge and De Jaeger, 2012; Benito Lòpez et al., 2011; Worthington and Dollery, 2005).

As there are similar research investigating the correlation between management models and waste services in the municipalities. Many of them have the aim of establishing a correlation between efficiency and public or private management models. Some authors find the mixed model to be more efficient, combining the benefits of the public and private sector (Ohemeng and Grant, 2014; Marcosin Adauto and Derval dos Santos, 2013), however, their perspective is not always the same, because other studies recognize a correlation between efficiency and privatization of urban hygiene services (Simoes and Marques, 2011).

Further studies carried out in countries in and outside the EU confirm the inefficiency of waste management by private companies (Simoes and Marques, 2012; Bel and Warner, 2008; Warner, 2012; Oduro-Kwarteng, 2011; Marcosin Adauto and Derval dos Santos, 2013).

One paper of interest, reviewing all the published econometric studies of water and waste production since 1970, highlights that there is no systematic optimal choice between public and private delivery: managers should approach the issue in a pragmatic

way (Bel and Warner, 2008) and this is confirmed in a similar research (Gonzàlez Gomez et al., 2013).

In addition, the correlation between efficiency and municipal cooperation has been investigated, reporting the benefits of inter-municipal cooperation in terms of administrative, economic and logistical efficiency improvement (Poldnurk, 2015).

3 Objectives

There are currently no studies analysing the correlation between efficiency and the complexity of the management models in use. Ideally these would establish whether models applied to several municipalities together benefit from leveraging on economies of scale, thereby increasing efficiency in urban hygiene services, as required by the current Italian legislation.

This paper aims to identify the most efficient management models operating in accordance with Italian regulatory requirements.

Efficiency analysis can be conducted for different reasons, in our paper it will be used to relate efficiency with the management model adopted and the size of the company providing the service.

We therefore chose to analyse the management of urban hygiene services, given the importance of service quality and its cost for citizens.

The treatment of urban waste is a "local public service of economic importance" and municipalities are financed directly through the contribution of citizens in order to provide it.

The need to maintain standards of efficiency is crucial, firstly, as an essential service for present and future wellbeing, and also because inefficiency increases the burden on the taxpayer.

Municipalities are not completely free to define their choice of management model: these models are provided by law and municipalities must also justify their choice in accordance with efficiency and effectiveness criteria with the Italian law directing the Municipalities in the aggregate management of public services in order to reach higher levels of efficiency.

In this context, our objective is to analyse the levels of efficiency in the management of municipal waste and to identify the most efficient management models.

The final purpose is to verify if recent laws introduced in Italian legislation that favour the increase in the size of the waste management companies, also increase their efficiency.

We have chosen to measure efficiency with the DEA method (Data Envelopment Analysis), a flexible and non parametric method that can be used to analyze the performance of multi input/output processes.

4 Methods

This analysis will be completed in two steps:

1. Analyzing the management model operating on integrated waste services in the Italian provinces. The data was acquired on the municipality websites or directly from the websites of the companies involved the waste management.

2. Analyzing the efficiency of the most widespread typology of society in order to obtain a ranking of the municipalities providing the highest quality service in relation to cost. As input, we use the cost of the service as taken from the official municipal annual report. As output, the tonnage of differentiated and undifferentiated waste collection.

For the efficiency analysis, we use DEAP software (Coelli, 1996), based on the DEA methodology.

Table 1: Input and output variables

Input			Output		
Variable	Year	Scale & source	Variable	Year	Scale & source
Costs for the waste disposal service	2013	Financial Statement Report of Municipalities	Total production of waste (quintals)	2013	City (ISTAT)
			Separate waste (quintals)	2013	City (ISTAT)

Legend:
As output variables, we considered:

- Total production of waste (quintals);
- Separate waste (quintals).

The data relating to the two output variables was retrieved from the site of the National Institute of Statistics (`www.istat.it`): we considered absolute values measured in quintals (the software DEAP works only with absolute values); unfortunately it was not possible to divide the separate waste for glass, paper etc, because of lack of information regarding many municipalities.

As input variables, we considered the costs for waste disposal services, taken from the Financial Statement Report of the municipalities (from the Ministry site – Ministero dell'Interno, `http://finanzalocale.interno.it` – and when there was a lack of information, we observed the website of single municipalities): data is reported in Euro and refer to the year 2013.

Eight cities were excluded from analysis for lack of data on the "commitments" : Aosta, Bolzano, Mantova, Perugia, Rieti, Trani, Venezia, and Vicenza. We verified the data given in the Financial Statement Report of the Municipalities and compared it with the data available on websites of each town: occasionally registering differences between the two data sources.

The decision to operate on a single year, 2013, is due to the objective of the research: to identify the most efficient model rather than the most efficient city. To this regard, we registered continuous changes in management models in full compliance with current regulations. This is due to legislation that encourages forms of management favouring cooperation between municipalities as well favouring the development of companies of wider dimension.

Five management models have been identified, two more than those established by law:

1. In-house providing, local government-owned corporation with just one municipality owning 100% of the equity capital.

2. In-house providing, a public equity corporation, where two or more municipalities directly or indirectly own 100% of the equity capital.

3. Company as a joint venture, with public and private equity where just one municipality and just one private subject directly own the equity capital.

4. Company with public and private capital, as a joint venture where two or more. municipalities and one or more private subjects directly and indirectly own the equity capital.

5. Entrepreneur or company, with private equity.

We have introduced the number 2 and number 4 management model, derived from the evolution of the in-house model and the public and private equity company. These models are more or less evolved and may lead to a very large company that can become corporate groups listed on the stock exchange.

The observed sample consists of 107 Italian cities, all of which are provincial capitals. Of the 107 cities observed, for four cities (Caserta, Chieti, Gorizia, Catania), we were unable to identify the management model, hence these cities were excluded from analysis concerning the management model.

The most popular models are number 1 (20%) and 2 (39%), both of them with 100% public equity capital; the least popular model is number 3 with only 7%.

The model numbers 2 and 4 (where municipalities manage the waste services together) represent more than 50%. This is in line with Italian and European regulations favouring larger management models, with the aim of increasing economies of scale (Poldnurk, 2015).

In Northern Italy, the most popular are number 2 (48%) and number 4 model (38%) with two or more municipalities that together dispense the urban hygiene service. The

Table 2: Territorial distribution of management model in Italy, year 2013

	GEOGRAPHICAL AREA							
Management Model*	Northern Italy (Abs. val.)	Northern Italy %	Central Italy (Abs. val.)	Central Italy %	Southern Italy (Abs. val.)	Southern Italy %	Total	Total %
1	3	7%	8	23%	10	38%	21	20%
2	20	48%	11	31%	9	35%	40	39%
3	3	7%	4	11%	–	–	7	7%
4	16	38%	3	9%	–	–	19	18%
5	–	–	9	26%	7	27%	16	16%
Total	42	100%	35	100%	26	100%	103	100%

*Source: website of Municipalities and the website of Ministero dell'Interno

number 5 model where the management of waste service is completely private is not present at all.

In Central Italy there is a more equitable distribution of the models, anyway model number 2, where two or more municipalities together participate in a public equity company, remains the most widespread (31%).

The situation is still different in Southern Italy, where the most popular are number 1 (38%) and number 2 (35%) with public equity, while the 27% of the municipalities have a private equity company. The company with a mixed, private and public, equity is completely absent.

The data collected on cities concerns resident population, the area in question and the management model adopted.

4.1 Data Envelopment Analysis

Efficiency measurements are based mainly on the use of non-parametric methods, such as the Data Envelopment Analysis (DEA) technique, (Cooper et al., 2011) which is particularly suitable for measuring the efficiency of decision-making units (DMUs), especially those active in local public services. It is a non-parametric analysis technique, which does not require the explanation of a production function, and is characterized by the possibility of determining the relative efficiency of similar decision units through linear programming techniques, without specifying the relative importance of the different factors of production (prices, distribution of efficiency). The measurement of efficiency, derived from the application of these methodologies, depends, in addition to the contextual conditions, also on the sample of analysed units, and in particular on the DMUs taken as reference.

Efficiency can be measured both by factors of production and products. In the first case, using the level of production and technology as data, input efficiency (INPUT ORIENTED approach), is obtained by the correspondence between the amount of input

actually used and the minimum potentially usable quantity. For products, given the technology and the level of use of inputs, output efficiency (OUTPUT ORIENTED approach), is determined by the relationship between the output actually achieved, and the maximum potential of that production (Biggeri et al., 2012).

The efficiency of a production unit can be broken up into two parts: technical efficiency and allocative efficiency (Farrel, 1957). The first is the ability of the production unit to achieve maximum output from a given (and limited) set of inputs. The allocative efficiency, instead, reflects the unit's ability to use optimal combinations of input and output, given their respective costs.

Technical and allocative inefficiency can occur either separately or jointly: therefore, all cases in which the costs are not minimized may depend on both technical inefficiency and allocative inefficiency.

The result of technical efficiency and allocative efficiency defines economic efficiency or cost efficiency.

Therefore, in an input-oriented perspective, a unit is considered efficient if, to obtain a given output, it maintains minimal costs. It has allocative efficiency when, given the level of production and technology, the inputs are combined so as to minimize the cost of production or, given the level of costs, to maximize output.

Technical efficiency (CRS, constant return to scale) can be decomposed into the production of "pure" technical efficiency (VRS, variable return to scale) and efficiency of scale. The assessment of efficiency requires the specification of all variables related, directly and indirectly, to the functions of production, cost, revenue or profit.

The explanation of the variables directly involved in the production process makes it possible to calculate the degree of inefficiency of individual units and define a list of all units tested.

5 Data analysis and results

The data were classified in four levels of efficiency. In the first class we find cities with an efficiency scale variable value between 0 and 10%, in the second, those with an efficiency variable scale value between 10-30%, in the third, those with variable scale efficiency between 30-70%, in the fourth, cities that reported an efficiency scale between 70% and 100%.

Table 3: List of Municipalities classified by management model and class of the efficiency

Efficiency classes	Total waste	Separate waste	Commitments	VRSTE*	Resident Population	Provincial Capitals	Management Model
0-10%	34890.70	9569.10	€ 21649310.53	0.001	70967.00	AQ	1
	45397.33	8836.96	€ 12531408.95	0.002	94903.00	BT-BARLETTA	1
	24927.33	15712.16	€ 16422932.91	0.002	60770.00	BN	1

Efficiency classes	Total waste	Separate waste	Commitments	VRSTE*	Resident Population	Provincial Capitals	Management Model
	27775.92	5652.11	€ 15500402.79	0.002	67403.00	PZ	1
	31728.29	5509.04	€ 8816007.80	0.003	60741.00	KR	1
	44748.66	8276.93	€ 11796774.83	0.003	69293.00	TP	1
	21034.59	2709.59	€ 7345035.06	0.004	49392.00	CB	1
	20580.38	7979.34	€ 6719409.04	0.004	37783.00	FM	1
	13994.75	9459.32	€ 5178518.18	0.005	35993.00	BL	1
	61483.28	40032.61	€ 35102716.51	0.014	133885.00	SA	1
	67486.26	19547.38	€ 23425145.48	0.016	121325.00	PE	1
	87861.38	31715.61	€ 36873726.61	0.020	160512.00	LI	1
	106917.07	10920.51	€ 47872906.00	0.023	203257.00	TA	1
	74295.56	49980.93	€ 15440474.13	0.054	76135.00	AT	1
	114528.01	7196.59	€ 42376707.38	0.067	241997.00	ME	1
	23298.41	14460.76	€ 13366262.49	0.002	54716.00	TE	3
	21663.45	4928.35	€ 9668933.67	0.003	42489.00	IM	3
	13930.08	7971.67	€ 8209386.14	0.003	37064.00	NU	3
	25824.08	10679.36	€ 7584892.23	0.004	50079.00	AP	3
	69132.29	36965.13	€ 18883979.26	0.021	94705.00	PU-PESARO	3
	43945.06	13070.05	€ 22474681.91	0.001	89165.00	BR	5
	39250.66	26384.97	€ 15444164.11	0.002	100333.00	BT-ANDRIA	5
	42642.80	1731.62	€ 10609381.23	0.003	91028.00	CZ	5
	29320.05	3990.11	€ 9576957.39	0.003	66558.00	VT	5
	15700.09	1475.19	€ 6053936.83	0.004	33675.00	VV	5
	13581.94	8944.53	€ 6056834.06	0.005	29228.00	CI-CARBONIA	5
	10551.86	7298.81	€ 5141290.59	0.005	27444.00	CI-IGLESIAS	5
	28556.19	6527.04	€ 590243621	0.005	60556.00	MT	5
	14084.15	8852.97	€ 5882193.15	0.005	31724.00	OR	5
	55526.85	8777.31	€ 18618988.41	0.009	93302.00	LE	5
	6003.08	3327.37	€ 2845640.40	0.009	11035.00	OG-TORTOLI	5
	54874.20	13953.56	€ 15304956.11	0.010	57889.00	OT-OLBIA	5
	60694.42	24851.69	€ 22763424.95	0.011	127715.00	SS	5
	18077.89	9670.46	€ 1991012.00	0.014	14367.00	OT-TEMPIO PAUSANIA	5
	89640.80	29426.06	€ 43124809.74	0.018	154019.00	CA	5
	82068.97	6433.64	€ 32656957.10	0.020	184937.00	RC	5
	22565.33	15390.87	€ 8517122.38	0.003	46992.00	VC	2
	35774.21	4304.37	€ 21479269.62	0.001	59010.00	AG	2
	47407.07	16713.20	€ 22266407.67	0.001	94535.00	SP	2
	32362.83	7211.17	€ 13565235.28	0.002	67910.00	CS	2

Effi-ciency classes	Total waste	Separate waste	Commitments	VRSTE*	Resident Population	Provincial Capitals	Manage-ment Model
	46648.86	15794.60	€ 19330131.18	0.002	81536.00	GR	2
	35542.47	8976.62	€ 13570243.11	0.002	72812.00	RG	2
	31117.38	7510.54	€ 11880480.48	0.002	61761.00	SV	2
	25674.32	14113.70	€ 10873173.84	0.003	55448.00	AV	2
	26907.71	13964.05	€ 9810018.77	0.003	45325.00	BI	2
	37750.63	16722.33	€ 9296015.38	0.003	71184.00	CR	2
	26919.06	4035.70	€ 8208553.16	0.003	46677.00	FR	2
	20414.07	10387.67	€ 8204567.05	0.003	41489.00	MC	2
	50653.04	27361.57	€ 2005475533	0.003	123151.00	MB	2
	43884.01	15335.04	€ 11854144.85	0.003	71297.00	PV	2
	22818.95	11775.85	€ 6884858.85	0.004	48131.00	LC	2
	22551.28	10837.81	€ 6501000.00	0.004	44529.00	LO	2
	27735.79	21424.67	€ 7234381.00	0.004	51758.00	PN	2
	31819.86	18310.97	€ 8282307.71	0.004	52099.00	RO	2
	48429.45	28924.10	€ 19090287.09	0.006	101742.00	AN	2
	12476.85	1145.04	€ 4181597.52	0.006	28280.00	EN	2
	10414.53	4177.74	€ 4138275.36	0.007	22095.00	SO	2
	53310.94	19211.25	€ 13552800.00	0.009	90192.00	PT	2
	61731.31	2380.54	€ 28094555.77	0.010	153143.00	FG	2
	63569.07	1879.35	€ 29573651.59	0.010	122304.00	SR	2
	56537.42	14579.75	€ 15875691.25	0.011	70202.00	MS	2
	56659.06	19435.78	€ 15196042.01	0.012	99232.00	AR	2
	4802.32	3388.92	€ 2094781.15	0.013	14274.00	VS	2
	10031.04	1097.72	€ 1892432.79	0.014	22061.00	IS	2
	68457.51	24198.37	€ 20029307.25	0.020	88627.00	PI	2
	53062.57	33326.23	€ 11764505.30	0.023	99528.00	UD	2
	1691.12	1024.86	€ 1025764.96	0.026	5556.00	OG-LANUSEI	2
	77531.00	38304.43	€ 20424941.99	0.027	93805.00	AL	2
	76012.99	33812.20	€ 7786839.17	0.068	55972.00	CN	2
	39950.18	13510.14	€ 11652904.16	0.002	84834.00	CO	4
	36386.56	13996.97	€ 13719352.56	0.002	54126.00	SI	4
	38967.26	21434.00	€ 15088843.20	0.002	80927.00	VA	4
	60487.03	33014.26	€ 17978332.27	0.014	89204.00	LU	4
	71092.11	21117.79	€ 24781855.91	0.018	125375.00	LT	4
	60668.73	36227.83	€ 18400000.00	0.020	118717.00	BG	4
	70732.19	38950.40	€ 19914950.81	0.023	102404.00	PC	4
	90307.38	23851.85	€ 33367048.51	0.024	204849.00	TS	4
	86326.93	42933.14	€ 28475307.53	0.025	133423.00	FE	4

Effi-ciency classes	Total waste	Separate waste	Commitments	VRSTE*	Resident Population	Provincial Capitals	Manage-ment Model
	99850.74	52965.37	€ 36782070.32	0.026	187938.00	PR	4
	83470.08	41563.70	€ 19131959.40	0.035	118359.00	FC	4
	41364.66	17845.41	€ 22379968.38	0.001	77099.00	CE	
	23656.76	14002.24	€ 10989640.97	0.003	52563.00	CH	
	15590.00	8527.02	€ 6041545.90	0.005	35349.00	GO	
10-30%	63903.17	25709.01	€ 1255135.01	0.247	112227.00	TR	1
	136216.28	60385.38	€ 42117711.71	0.299	191268.00	PO	1
	130680.49	60357.80	€ 42119000.00	0.241	259966.00	VR	2
	76985.02	52568.94	€ 6476719.48	0.141	31053.00	VB	2
	112236.17	62876.77	€ 31208798.25	0.161	172525.00	RE	4
	129260.54	59340.15	€ 44811656.00	0.210	209678.00	PD	4
30-70%	186686.95	39864.69	€ 63062825.10	0.544	322751.00	BA	1
	94069.81	66563.86	€ 14770965.50	0.663	104736.00	NO	1
	496554.89	100921.16	€ 253863162.48	0.698	989111.00	NA	1
	52489.92	38148.63	€ 816492.34	0.527	117285.00	TN	3
	232729.95	97301.16	€ 88784661.73	0.676	377207.00	FI	2
	131263.21	50184.95	€ 29777393.50	0.341	193599.00	BS	4
	116151.12	71227.90	€ 37335302.00	0.424	146856.00	RN	4
	123443.99	71062.37	€ 31080098.29	0.502	184525.00	MO	4
	199877.23	71367.67	€ 69487405.78	0.605	384202.00	BO	4
	204713.22	20597.00	€ 69786369.06	0.604	315576.00	CT	
77%	305864.08	96229.18	€ 119092000.00	0.769	596958.00	GE	1
99%	449698.58	197103.15	€ 179795276.75	0.992	902137.00	TO	3
100%	339608.30	34403.17	€ 100942822.06	1.000	678492.00	PA	1
	1754822.52	521023.00	€ 777567453.91	1.000	2863322.00	RM	1
	30983.47	3920.72	€ 27000.00	1.000	63034.00	CL	2
	48514.18	26242.13	€ 30983.70	1.000	83145.00	TV	2
	650669.61	276575.51	€ 280936365.97	1.000	1324169.00	MI	4
	11065.44	59878.18	€ 1159673.38	1.000	158784.00	RA	4

*VRSTE is the variable return scale technical efficiency.

Full efficiency was registered in only six municipalities (see table 3).

Turin, with an efficiency scale variable of 99%, is positioned close to the efficiency frontier .

If we divide the municipalities analysed in four classes of efficiency we see that:

- the first class [70-100%] includes 7% of the capitals analysed;

- the second class [30-70%] includes 9% of the capitals analysed;
- the third class [10-30%] corresponds to 6% of the provincial capitals;
- the fourth class [0-10%] corresponds to 78% of the municipalities analysed.

For each management model, we determined the average efficiency. The first model has an average efficiency of 23%, the third model 22%, the fourth model 23%. The second and the fifth model has a very low average efficiency (Fig. 1).

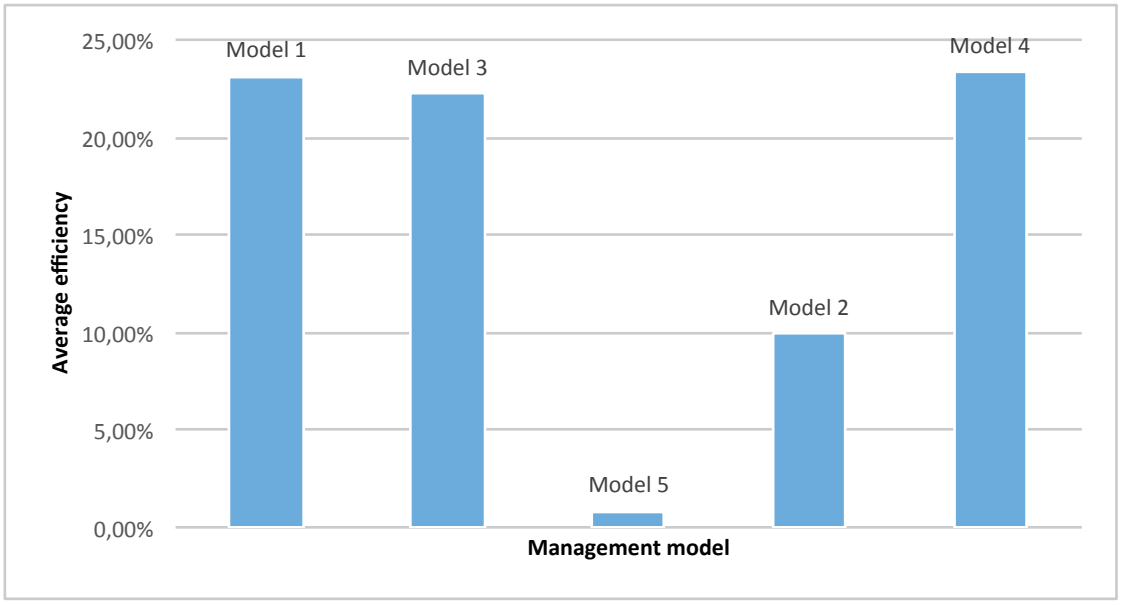

Figure 1: Average efficiency reached by each management model.

Subsequently, for the efficiency classes of primary interest, namely the first and second class (30%- 70% and 70%-100%), we evaluated the classes in terms of management models (table 3). In these two average efficiency classes:

- 37% of municipalities adopt 100% public equity management model (no. 1).
- 25% of municipalities implement 100% public equity management model whit two or more municipalities (no. 2).
- 25% of municipalities have public and private equity management model (no. 3).
- 13% of municipalities use public and private capital with two or more municipalities (no. 4) .

The most important evidence relates to the absence of the private management model (number 5) from the first and second class of efficiency: the cities which chose outsourcing services, are all included in fourth class, full inefficiency.

Through the DEA results, obtained using Deap software, we can observe the inefficiency of Italian municipalities in waste management in the year 2013.

In particular, in the fourth class of efficiency, characterized by an efficiency scale variable between 0 and 10%, there are 83 municipalities over 107 analysed, that represent 78% of the sample: a large majority of municipalities has not reached an efficient performance.

We have also analysed the relationship between the efficiency and the municipality size. We ordered the municipalities per population classes, considering the first two classes of efficiency (30%-70% and 70%-100%).

Table 4: The relationship between population and the first two classes of efficiency

Population Class (x1000)	Resident Population	Total waste	Separate waste	Commitments (€)	VRSTE*	Provincial Capitals	Management Model
60-80	63034	30983.47	3920.72	27000	1	CL	2
80-100	83145	48514.18	26242.13	30983.7	1	TV	2
100-150	146856	116151.12	71227.9	37335302	0.424	RN	4
	117285	52489.92	38148.63	816492.34	0.527	TN	3
	104736	94069.81	66563.86	14770965.5	0.663	NO	1
150-200	193599	131263.21	50184.95	29777393.5	0.341	BS	4
	184525	123443.99	71062.37	31080098.29	0.502	MO	4
	158784	110653.44	59878.18	1159673.38	1	RA	4
200-500	322751	186686.95	39864.69	63062825.1	0.544	BA	1
	184525	123443.99	71062.37	31080098.29	0.502	MO	4
	377207	232729.95	97301.16	88784661.73	0.676	FI	2
>500	989111	496554.89	100921.16	253863162.5	0.698	NA	1
	596958	305864.08	96229.18	119092000	0.769	GE	1
	902137	449698.58	197103.15	179795276.8	0.992	TO	3
	678492	339608.3	34403.17	100942822.1	1	PA	1
	1324169	650669.61	276575.51	280936366	1	MI	4
	2863322	1754822.52	521023	777567453.9	1	RM	1

We noticed that six, of the 17 municipalities belonging to the first and second-class efficiency, have more than 500.000 inhabitants, differently to what stated in other researches (Carvalho et al., 2015), where greater efficiency is found in medium-sized cities.

We also noticed that the most popular model is number 1, with a 100% public equity, in the cities with a large population and a great efficiency. None of the six cities with

more than 500.000 inhabitants adopts a management model to private equity.

6 Conclusion

Our analysis confirms that municipalities are not efficient in coping with urban hygiene services.

In fact, only seven municipalities out of 107 demonstrate high levels of efficiency.

If we analyse the management models among the top seven municipalities, there is no municipality that has outsourced the service to a company with completely private equity capital.

In fact, the first municipality that has this management model has a level of efficiency/inefficiency of 2%.

The municipalities that adopt advanced management models with different municipalities managing the waste services are more efficient, whether they have public or private and public equity.

To confirm that a spatial dimension greater than that of the municipality is necessary to take advantage of economies of scale, we note that in the first class of efficiency, there are, generally, large cities.

Broader management models are the most efficient, in fact, are the most numerous in the first and second-class efficiency groups.

This confirms the validity of the existing legislation, which seeks to promote cooperation between municipalities in order to exploit economies of scale.

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