EMPIRICAL ANALYSIS OF SOLID MANAGEMENT WASTE COSTS: SOME EVIDENCE FROM GALICIA, SPAIN

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Abstract: This paper analyses the factors that determine solid waste service costs. The empirical analysis is based on information derived from a survey conducted in a sample of Galician municipalities. The results reveal economies of scale in municipalities of fewer than 50,000 inhabitants, such that cooperation between these municipalities could lead to cost savings. It also appears that private delivery is not cheaper than public delivery. Finally, designating a larger proportion of the total waste volume to recycling does not imply greater costs.
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Key words: solid waste services, costs, local government

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1. Introduction

In recent years solid waste services have undergone operational reorganization in many countries. This organizational change has gone hand in hand with increasing calls for better functioning and results, not only in terms of tailoring services to improve the quality of everyday life in urban centers but also as a consequence of greater concern over sustainability and environmental protection. However, despite the extent of changes to these services very few empirical analyses have been conducted as regards their economic aspects, this being especially the case outside the USA.

The present study aims to provide a detailed empirical analysis of the factors that determine solid waste service costs. Attention is focused on municipalities in metropolitan areas of the Spanish region of Galicia, and the analysis is based on information derived from a survey of 65 such municipalities. Cost structure is studied in order to explain the variability between municipalities as regards service costs. To this end, a function of municipal costs is determined and estimated parametrically. The results of the empirical analysis enable us to study the existence of economies of scale with respect to output, as well as the effect of certain factors directly related to the service, for example, the proportion of selective waste, the frequency of collection or the existence of municipal incineration plants. The paper also analyses the impact on costs of other local factors such as seasonal variations and the form of service production.

2. Empirical background on estimates of solid waste costs

The empirical literature regarding factors that might explain solid waste service costs dates back to the mid 1960s. Given the progressive improvement in available databases, as well as in the econometric techniques used, it is worthwhile reviewing this literature in chronological order. Thus, the next section begins by considering the pioneering studies, especially that of Hirsch (1965), who was the first author to make an important methodological contribution. Attention then shifts to the second generation of research, particularly the work of Stevens

(1978), who made substantial improvements to the model of Hirsch (1965), and that of Dubin and Navarro (1988), whose paper also includes methodological innovations. Finally, the review looks at studies published over the last decade and which have used more robust statistical methods and more detailed databases. Therefore, each of these more recent studies is considered in greater detail.

2.1. Pioneering studies

The first empirical study to use econometric analysis to determine, among other things, whether the form of service delivery (public or private) had an effect on municipal costs was that of Hirsch (1965), who sampled 24 municipalities in St. Louis County (Missouri). Although he started from a more ambitious model in terms of explanatory variables his empirical study was limited by the data available in 1960, the year for which he obtained information. Therefore, the variables that were finally used to explain costs (taken as mean costs per service) were the number of collection units, the weekly collection frequency, whether the collection point was individual or collective, the residential density, the type of service financing (general budget or specific tax) and the form of service management, distinguishing between municipal and private delivery. Following his empirical analysis, Hirsch (1965) found no significant differences in service costs between municipal and private delivery. Interestingly, neither did he find any economies of scale with respect to output (hereinafter, economies of scale) in the service.[1]

The model proposed by Hirsch (1965) was, with slight variations, followed in subsequent studies by Kitchen (1976) in Canada, Kemper and Quigley (1976) and Collins and Downes (1977) in the USA, and Pommerehne and Frey (1977) in Switzerland. Except for the study by

[1] In this regard it is worth clarifying a methodological aspect. Economies of scale imply that mean costs fall as output rises, whereas economies of density refer to variations in mean costs with respect to changes in the concentration of the population served.

Collins and Downes (1977) all these papers argue that private delivery has significantly lower costs.

2.2 Second generation of research

The models specified in the abovementioned studies were highly preliminary, and the research was also subject to important limitations due to the lack of data. However, toward the end of the 1970s a number of studies appeared that used increasingly better quality data (for example, the amount of waste generated) and/or more robust statistical techniques.

The study by Stevens (1978) was an important step forward in terms of the quality of both model specification and the data used. This author sampled 340 private firms and public entities that provided a solid waste service to 340 cities distributed across the whole of the USA. The study considered questions related to the form of production (competitive markets with private agreements between families and private providers, public monopoly or private monopoly under contract to the municipality), and also took a more formal approach to issues regarding economies of density. Stevens took as her explained variable the total service cost, while the explanatory variables were the amount of waste generated, a wage index for the sector, the form of production (private or public), the market structure (competitive or monopoly), the frequency of collection, the amount of waste per inhabitant, the population density and the variability in climatic conditions. The empirical findings reported by Stevens (1978) show the existence of positive economies of scale in less-populated municipalities, but there was no evidence of economies of density. Furthermore, the frequency of collection and wage indicators were found to have a positive influence on costs, whereas variations in climate had no effect.

Finally, with respect to the form of provision, private provision with competition between firms was significantly more expensive than a monopoly approach, regardless of whether the latter was public or private. As regards the comparison between public monopoly and private

monopoly, Stevens (1978) found that with fewer than 50,000 inhabitants there were no significant differences between the two kinds of production forms, whereas above 50,000 inhabitants private monopolies were associated with lower costs than public ones.[2]

The model proposed by Stevens (1978) was widely followed in the literature, it being applied with very few variations by Tickner and McDavid (1986) in Canada — where the authors report lower costs for private delivery — and by Domberger, Meadowcroft and Thompson (1986) in the UK, where no difference was found between the cost of public and private delivery when a competitive tendering system was in place.

Dubin and Navarro (1988) address the same questions as were considered by Stevens (1978) and Tickner and McDavis (1986). Using the same sample as in the study by Stevens, and with complete data for 261 municipalities, Dubin and Navarro took as their explained variable the average service cost, while the explanatory variables considered were the amount of waste collected per household, the market structure (private, franchise-based or municipal provision, regardless of whether the latter was based on public delivery or contracting out), the frequency of collection, whether collection was from homes or waste deposit points, the population density and the variability in climatic conditions. The empirical results reported by Dubin and Navarro coincide with those of Stevens as regards the existence of positive economies of scale in municipalities with fewer than 20,000 inhabitants, although the importance of these economies of scale was very limited. With more than 20,000 inhabitants the economies of scale no longer held true, and neither did the authors find any direct evidence of economies of

[2] The results obtained when segmenting the municipalities by population size led Stevens (1978) to propose the existence of a structural change in the equation that would make the sample aggregation incorrect, although she found no solid statistical evidence of this.

density.[3] Moreover, the greater the collection frequency the higher the costs, whereas the latter were reduced when waste was collected from deposit points. Variations in temperature had no significant effect. As regards the type of provision, the most expensive was the private approach, followed by a private monopoly with franchising (Dubin & Navarro, 1988). The least expensive forms of service were those based on contracting out and municipal provision. Finally, these authors also studied the suggestion made by Stevens (1978) regarding a structural change in the cost equation according to population size, but found no evidence to reject the hypothesis of structural stability in this equation.

In line with the research by Domberger, Meadowcroft and Thompson (1986), a subsequent study by Szymanski and Wilkins (1993) used information about municipalities in England and Wales with samples covering the five-year period from 1984 to 1988. They found no significant difference in the costs of public and private delivery when a competitive tendering system was in place. Finally, Szymanski (1996) reported that tenders awarded to private firms led to greater cost savings than did those won by public bodies. However, in both cases the advantages of competitive tendering diminished over time, this occurring more quickly in the case of tenders awarded to public firms as compared with those won by private firms.

2.3. The most recent studies

In recent years a number of empirical studies have been published which use not only more detailed data about solid waste services but also progressively more sophisticated statistical techniques.

[3] With respect to economies of density, Dubin and Navarro (1988) consider the possible correlation between population density and the type of service organization, which could affect the consistency of the density estimate and explain its lack of significance in previous studies. After correcting their model with the effect of the market structure they found positive economies of density.

Reeves and Barrow (2000) worked with a sample of 48 municipalities in Ireland and used information covering the years 1993, 1994 and 1995. Taking as their explained variable the total cost of waste services they considered a series of explanatory variables related to output and other service characteristics such as the number of collection units (approximation to output), as well as variables regarding service frequency, the type of collection, the importance of costs derived from selective waste, residential density, and whether or not delivery was public or private. On the basis of their empirical analysis Reeves and Barrow (2000) argue that private delivery was associated with cost savings in each of the years studied, and also that these savings were very high.

Callan and Thomas (2001) considered the possible multi-product nature of solid waste services, distinguishing between their two main components: general waste for disposal and selective waste for recycling. The empirical analysis was based on a sample of 110 municipalities in Massachusetts (USA), using information for the year 1997. Callan and Thomas estimated a two-equation model in which the explained variable was service cost (of disposal, on the one hand, and recycling on the other), while the explanatory variables were the amount of waste generated, the population density, the frequency of collection, the form of service delivery (public monopoly or contracting out), and the existence of a municipal dump, among others. In the case of waste for disposal the empirical analysis revealed economies of density but no economies of scale, whereas for recyclable waste there were economies of scale but no economies of density. The authors also found economies of scope for both disposal and recycling services. A greater collection frequency was associated with higher costs in both cases, while the existence of a municipal dump reduced costs. Finally, the form of delivery had no effect on cost (Callan & Thomas, 2001).

Dijkgraaf and Gradus (2003) studied solid waste service costs in a sample of 85 municipalities in the Netherlands for the period 1996-97. Taking total service cost as their

explained variable the authors assumed coverage of 100% by means of taxes and estimated costs as the product of service taxes and the number of households. The variables used to explain total costs were related to service output, for example, the number of collection points, the density of collection points and the type of collection. They also considered the frequency of service and variables that reflect recycling characteristics such as the percentage of glass, paper and organic matter. Finally, a distinction was made between public and private service delivery. This study also made use of the Chow test, which measures the structural stability of cost equations. Dijkgraaf and Gradus (2003) compared the structural stability of the cost equation for both the size of municipality and the form of delivery. As regards costs according to the model of delivery the authors found that contracting out was associated with lower costs, although there were no significant differences between public and private delivery in this respect.

Ohlsson (2003) worked with a sample of 170 companies in 115 Swedish municipalities using information for the year 1989. In order to explain total costs Ohlsson considered explanatory variables related to the product (amount collected, frequency of service), the distance covered by waste transport, the price of inputs (labour and capital) and the form of delivery. The author then compared the stability of the cost equation for the different forms of delivery. This comparison is indeed important because if, as Ohlsson found, there is structural instability between public and private delivery, then a dummy variable according to the form of production would constitute an incorrect specification for the cost comparison. In all other respects, and as in the abovementioned studies, Ohlsson specified a cost function akin to that proposed by Stevens (1978). The study also applied various technical corrections to increase the robustness of the econometric estimate. The results obtained suggest that public delivery is cheaper than a private service (Ohlsson, 2003).

The studies by Bel (2006) and Bel and Costas (2006) constitute the first econometric analyses in Spain of the municipal costs of solid waste services. The research used a sample of 186 municipalities in Catalonia and the information gathered was for the year 2000. In order to explain the total cost of solid waste services, these works consider variables related to the volume of product (amount of waste generated), the price of inputs (wage costs), certain characteristics of the product (frequency of the service, availability of dumping sites, form of production, i.e. public or private), and certain uncontrollable characteristics that affect the service, such as population density and the strength of the tourist factor. In general, these explanatory factors are in line with those used in the abovementioned studies, although the specification of a tourism variable, based on the degree of such activity, is a novelty in the literature. The empirical analysis found significant economies of scale in the less-populated municipalities. However, the strength of these economies of scale was limited and, indeed, both their intensity and significance disappeared as population increased. In fact, the test of structural change indicated the advisability of studying larger municipalities separately from smaller ones. As regards the association between form of production and service costs there were no significant differences between public and private delivery.

Finally, Dijkgraaf and Gradus (2007) analysed the factors which determined the total costs of waste services in 453 municipalities in the Netherlands for the year 2002. This study used the same control variables as those employed by Dijkgraaf and Gradus (2003) to explain total costs of service delivery at the municipal level: number of collection points, density of collection points, type of collection, frequency of service, characteristics of recycling, and form of production. Additionally, they included a series of concentration indicators at the provincial level to analyze the extent to which the strength of competition affects the impact of contracting out on costs, taking into account that in the Netherlands contracting out may involve both public and private companies. The concentration indicators used were the

Hirschman-Herfindahl index, the C3-ratio (the market share of the three largest companies) and the presence of competitors (private or public) in municipalities within the same geographical area. Although the results for the other explanatory variables were very similar to those reported by Dijkgraaf and Gradus (2003) the authors found evidence to suggest that cost savings with contracting out depended on the degree of concentration at the provincial level: the greater the concentration the lower the cost savings associated with contracting out. In addition, they found that the presence of public (but not private) companies as competitors in neighboring municipalities seemed to have a positive effect on the cost savings achieved with contracting out.

3. The model for analyzing solid waste service costs in Galicia

Having reviewed the published multivariate empirical studies it is now possible to propose a general model for estimating the factors that determine solid waste service costs:

$g = \mathrm{f}(q, p, x, z)$,

where g is the municipal cost (cost borne by the municipality), q is the volume of output, p is the price of inputs, x the characteristics of output, and z the uncontrollable characteristics that affect the service.

In order to conduct the empirical analysis on the basis of this general model it is necessary to have data regarding the target variables for a broad sample of Galician municipalities. The empirical model to be estimated is as follows, taking logarithms of both the dependent variable and the explanatory variables:

$$LCT = \alpha + \beta_1 LOUTPUT + \beta_2 LPERSELECT + \beta_3 LFREC + \beta_4 LTURIS + \beta_5 LPLANTS + \beta_6 LWAGES + \beta_7 D^{PRIV} + \varepsilon \quad (1)$$

In this equation the dependent variable is the total cost of service delivery, *LCT*. Insofar as the cost data for municipalities using private delivery are provided by local government, these are costs incurred by the municipality, and thus we are dealing with municipal costs or

spending rather than production technical costs. Here, service is understood to mean the set of activities implied by this term: a) collection; b) transport; and c) disposal (dumping or incineration) or recycling (valorization). Also included are the following explanatory variables with respect to municipal costs or spending:

1) LOUPUT. Volume of waste collected in the municipality, expressed in kilos. One would expect to find a positive relationship between the volume of waste generated and total costs. Therefore, the coefficient associated with this variable should be positive. In fact, the volume of waste generated should be the main factor determining the total cost incurred by the corresponding municipality. However, the value of the coefficient associated with this variable will determine whether or not there are economies of scale. In the event that this value is less than 1, and significantly so, this would provide evidence that costs increase less than proportionally with increases in output.

2) LPERSELECT. Percentage of the total waste volume that is designated for recycling. Except for those municipalities with the largest population (over 50,000 inhabitants) it has been possible to gather separate information regarding waste sent for disposal (dumping or incineration) and that sent for recycling (selective waste). One would expect to find a positive relationship between the percentage of waste designated for recycling and costs, such that the coefficient of this variable should be positive.

3) LFREC. The frequency of waste collection, in other words, the number of days per week on which waste is collected. Given the findings of previous studies this variable is expected to show a positive effect on costs.

4) LTURIS. Level of tourist activity in the municipality. This variable aims to reflect the influence on costs of seasonal variation in the generation of solid waste. Indeed, during the tourist season it may be necessary to take on extra staff and this introduces some instability

into service production. Hence the coefficient associated with this variable is expected to be positive.

5) LPLANTS. Dummy variable that takes the value of 1 in the event that there is an incineration plant within the municipal district, and 0 otherwise. The existence of an incineration plant within the municipal district may enable the cost of transporting waste from collection points to the incineration site to be reduced. Therefore, the coefficient associated with this variable is expected to be negative.

6) LSL. Mean wage per employee at the provincial level. The coefficient associated with this variable is expected to be positive, since higher wages inevitably imply higher salary costs.

7) D^{PRIV}. Dummy variable that takes the value of 1 if delivery has been contracted out to a private firm, and 0 in all other possible scenarios: a) local government provides the service directly (waste management department or independent body); (b) the service is provided by a municipal company (subject to private law). It is not clear what the expected effect of this variable should be, since the results of the literature are not conclusive. In fact, determining the sign of the relationship between the form of production and costs has been one of the aspects that have received most attention in the literature. In this regard, it is worth noting the high percentage of municipalities in the sample in which the service is provided by a private firm. Indeed, in one third of the municipalities for which information on service delivery was available, this service had been contracted out to private companies.

4. Estimation and results

The empirical analysis is based on data obtained for the year 2005. The information about total costs incurred by municipalities for solid waste services, as well as that referring to the total volume of waste generated, the existence or not of an incineration plant within the municipal district, the frequency of collection and the form of production was gathered via a

survey drawn up by a team of researchers at the Autonomous University of Madrid. The data obtained through this survey, which was designed especially for the present study, was complemented by information provided via the Survey of Equipment and Infrastructure conducted by Spain's Ministry for Public Administration for municipalities of fewer than 50,000 inhabitants. In addition, the variable regarding tourist activity refers to the indicator published by the Socio-economic Atlas of Galicia, using information contained in the yearbook of the Spanish saving bank *La Caixa*. This index is calculated on the basis of the revenue received through the business tax payable by hotels and related establishments.

The data collection procedure yielded sufficient and complete information for 65 municipalities in Galicia. Table 1 shows the degree to which the municipalities in the sample are representative of the total number in Galicia. Thus, it can be seen that information has been obtained for municipalities that account for 51% of the total population of this autonomous region of Spain.

Insert Table 1

Indeed, the degree of representation achieved by the sample can be considered very high for municipalities of more than 10,000 inhabitants, with response rates of more than 55% in terms of both municipalities and population. For municipalities of between 5,000 and 10,000 inhabitants the degree of representation is adequate, at around 25% of the total for municipalities and population. The sample is less representative for municipalities of fewer than 5,000 inhabitants, and especially for those at the lower end of this band.

Tables 2 and 3 show the descriptive statistics and the correlation matrix of the variables used in the empirical analysis. The range of variation in the data for each of the variables seems to be large enough to capture adequately their influence on the costs of solid waste collection. The only exception is the variable referring to wage costs in the province, where the variability is rather modest.

Insert Table 2

Insert Table 3

As expected, the strongest correlation is observed between the volume of waste generated and total costs. Moreover, it should be noted that the correlations between the explanatory variables used in the multivariate analysis are not too high, and therefore one would not expect there to be a problem of multicolinearity.

The estimation was performed using the ordinary least squares estimator. The standard errors correct any problems of heteroskedasticity which may arise from the estimation of cross-sectional data.

Since data for the volume of selective waste were not available for municipalities with a large population, the estimation was performed for two different samples. The first estimation considered all the municipalities in the sample without including the variable referring to the percentage of selective waste over the total, as this was not available. In a second estimation we then considered all those municipalities with fewer than 50,000 inhabitants and included the selective waste variable.

Note that several previous studies have shown that the estimation should be made for sub-samples of municipalities according to population bands, since the differences between large and small municipalities may be relevant (Bel, 2006; Bel & Costas, 2006; Dubin & Navarro, 1988; Stevens, 1978). However, the small number of available observations did not enable robust estimations to be made for sub-samples of large and small municipalities.

Tables 4 and 5 show, respectively, the results of the estimations that consider all the municipalities in the sample and those with fewer than 50,000 inhabitants. The explanatory power of the model overall is very high in both cases, since R^2 is in the range of 80-85%. This figure is consistent with the results of previous studies. Also shown are the variance inflation factors (VIF) in order to determine the possible existence of multicolinearity due to an

excessive correlation between the explanatory variables. In all cases, the VIF obtained are very low, thus confirming that there is no problem of multicolinearity.

Insert Table 4

Insert Table 5

As expected, the variable referring to the amount of waste collected is clearly significant. However, the most relevant aspect of this variable is not its statistical significance, but rather the value of its coefficient. Indeed, for there to be economies of scale the total cost must increase less than proportionally with respect to the volume of waste generated. Therefore, for economies of scale to exist this coefficient (β_1) must be less than 1.

Tables 4 and 5 show the one-tailed comparison for the absence of economies of scale (Ho: $\beta_1 \geq 1$). This comparison does not confirm economies of scale when the whole sample of municipalities is considered. However, for those with fewer than 50,000 inhabitants there do seem to be economies of scale. These results are consistent with previous findings. Indeed, Bel (2006), Bel and Costas (2006), Callan and Thomas (2001), Dubin and Navarro (1988) and Dijkgraaf and Gradus (2003) all failed to observe economies of scale when considering all the municipalities sampled, whereas Bel (2006), Bel and Costas (2006), Dubin and Navarro (1988) and Stevens (1978) did find economies of scale when analyzing those with a lower population.

This finding suggests that cooperation between municipalities could lead to cost savings insofar as this cooperation implies aggregating the volume of waste generated by each one.

It is important to point out that the results of the estimation also suggest that private delivery is not necessarily cheaper than a public service. Thus, the dummy variable that takes a value of 1 for private delivery has a positive sign and is significant, although only at the 10% level, in the estimation that considers all the municipalities sampled.

In this regard, there is no consensus in the literature about the ability of private delivery to reduce the costs of solid waste collection services (Bel, Hebdon and Warner, 2007; Bel &

Warner, 2008). A priori, private delivery should enable cost savings by taking greater advantage of economies of scale, by having a better incentive structure and through the possible introduction of competition for the contract. In the case of the present sample, however, it does not appear that these advantages have materialized. As such it should be taken into account that privatization implies additional transaction costs derived from drawing up and overseeing the contract with a company that is external to the municipality. Moreover, competition for the contract is, in many cases, limited insofar as the concentration of companies and the monopolization of the contract by the first incumbent are typical in this sector. Because of this, more importance must be given to regulatory policies (Massaruto 2007, Warner and Bel, 2008) and the design of regulatory institutions (Cunha Marques and Simoês 2008).

As regards the estimation for municipalities of fewer than 50,000 inhabitants the variable referring to the percentage of the total volume of waste that is designated for recycling is not significant. Therefore, the environmental advantages derived from promoting recycling activities do not seem to lead to an important increase in the cost of solid waste collection. Hence, the present results suggest that local government would do well to promote such recycling activities.

As expected, the level of tourist activity was significantly and positively associated with the total cost of waste collection, as was the frequency of collection. In contrast, the existence of an incineration plant within the municipal district led to a significant reduction in costs. This was the case not only for the estimation that considered all the municipalities sampled, but also for that which analyzed those with fewer than 50,000 inhabitants.

Finally, the variable referring to wage costs was not significant, probably as a result of the scarce variability of the sample considered. Unfortunately, data in this regard were only available at the provincial level, and not at the municipal level.

5. Conclusions

The adequate and efficient delivery of solid waste services is of great importance in terms of both people's everyday lives and local government finances. In this regard, new forms of organization and service delivery have been implemented in many countries in order to improve services.

The present study has used an empirical analysis to identify the factors that determine the costs of providing solid waste collection services at the municipal level. This has been done using information concerning a sample of municipalities in the Spanish region of Galicia.

The main results of the empirical analysis are as follows. Firstly, economies of scale are clearly available to smaller municipalities. Secondly, private delivery does not imply cost savings, but rather tends to increase the costs incurred by municipalities in running a solid waste service. Moreover, a high proportion of selective waste collection does not appear to increase total costs, aside from the important improvements it brings in environmental terms. Finally, various aspects related to the characteristics of the municipality (level of tourist activity, whether or not there are incineration plants) or the quality of service (frequency of collection) have an influence on the costs of solid waste collection services.

In summary, there are aspects beyond the control of local government that affect the cost of providing a solid waste service, for example, the level of tourist activity or the size of a municipality's population. However, policies designed to promote recycling do not appear to be too costly for local authorities. Finally, there is no evidence to suggest that private delivery leads to cost savings for municipalities. Beyond the debate about public versus private delivery, however, the setting up of cooperation agreements between municipalities may reduce service costs for those with small populations, insofar as they would make it possible to take advantage of economies of scale.

Acknowledgments

Financial support for this research has been provided by the Spanish Commission of Science and Technology (SEJ 2006-04985). We are particularly thankful to José María Mella.

Referencias

Bel, Germà (2006), "Un análisis de los gastos municipales por el servicio de residuos sólidos urbanos," *Revista de Economía Aplicada*, 14 (41), 5-32.

Bel, Germà and Antón Costas (2006), "Do public sector reforms get rusty? Local privatization in Spain," *Journal of Policy Reform,* 9 (1), 1-24.

Bel, G., Hebdon, R., Warner, M. (2007), "Local government reform: privatization and its alternatives," *Local Government Studies,* 33(4), 507 - 515

Bel, Germà and Midred Warner (2008), Does privatization of solid waste and water services reduce costs? A review of empirical studies, *Resources, Conservation & Recycling*, 52(12), 1337-1348

Callan, Scott J. and Janet M. Thomas (2001), "Economies of scale and scope: A cost analysis of municipal solid waste services," *Land Economics*, 77 (3), 548-560.

Collins John N. and Bryan T. Downes (1977), "The effect of size on provision of public services: The case of solid waste collection in smaller cities," *Urban Affairs Quarterly*, 12 (3), 333-347.

Cunha Marques, Rui, and Pedro Simões (2008), "Does the sunshine regulatory approach work? Governance and regulation model of the urban waste services in Portugal," *Resources, Conservation & Recycling*, 52(8/9): 1040-49.

Dijkgraaf, Elbert and R.H.J.M. Gradus (2003), "Cost savings of contracting out refuse collection," *Empirica*, 30 (2), 149-161.

Dijkgraaf, Elbert and Raymond Gradus (2007), 'Collusion in the Dutch waste collection market', *Local Government Studies*, 33 (4), 573-588.

Dubin, Jeffrey A. and Peter Navarro (1988), "How markets for impure public goods organize: the case of household refuse collection," *Journal of Law, Economics & Organization*, 4 (2), 217-241.

Hodge, Graeme (2000), *Privatization. An International Review of Performance*. Boulder (CO): Westview Press.

Kemper, Peter and John Quigley (1976), *The Economics of Refuse Collection*. Cambridge (MA): Ballinger.

Kitchen, Harry M. (1976), "A statistical estimation of an operating cost function for municipal refuse collection," *Public Finance Quarterly*, 4 (1), 56-76.

Massarutto, Antonio (2007). "Municipal waste management as a local utility: Options for competition in an environmentally-regulated industry. *Utilities Policy*, 15(1): 9-19.

McDavid, James C. (1985), "The canadian experience with privatizing residential solid waste collection services," *Public Administration Review*, 45 (5),602-608.

Ohlsson, Henry (2003), "Ownership and production costs. Choosing between public production and contracting-out in the case of Swedish refuse collection," *Fiscal Studies*, 24 (4), 451-476.

Pier, William J., Robert B. Vernon and John H. Wicks (1974), "An empirical comparison of government and private production efficiency," *National Tax Journal*, 27 (4), 653-656.

Pommerehne, Werner W. and Bruno Frey (1977), "Public versus private production efficiency in Switzerland: A theoretical and empirical comparison," en Vincent Ostrom y Robert B. Pendell, eds., *Comparing urban service delivery systems. Urban Affairs Annual Review*, 12, 221-241.

Reeves, Eoin and Michael Barrow (2000), "The impact of contracting-out on the costs of refuse collection services.The case of Ireland," *Economic and Social Review*, 31 (2), 129-150.

Stevens, Barbara J. (1978), "Scale, market structure, and the cost of refuse collection," *Review of Economics and Statistics*, 60 (3), 438-448.

Szymanski, Stefan (1996), "The Impact of compulsory competitive tendering on refuse collection services," *Fiscal Studies*, 17 (3), 1-19.

Szymanski, Stefan and Sean Wilkins (1993), "Cheap rubbish? Competitive tendering and contracting out in refuse collection," *Fiscal Studies*, 14 (3), 109-130.

Tickner, Glen and James C. McDavid (1986), "Effects of scale and market structure on the costs of residential solid waste collection in Canadian cities," *Public Finance Quarterly*, 14 (4), 371-393.

Warner, Mildred and Germà Bel (2008), "Competition or monopoly? Comparing privatization of local public services in the US and Spain", *Public Administration*, forthcoming.

Warner, Mildred and Amir Hefetz (2003), "Rural – urban differences in privatization: limits to the competitive state," *Environment and Planning C: Government and Policy*, 21(4), 703-718.

TABLES

Table 1. Representativeness of the sample of municipalities

	Municipalities included in the analysis					
Number inhabitants	**<5.000**	**5.001-10.000**	**10.001-20.000**	**20.001-50.000**	**>50.000**	**Total**
Number Municipalities	13	18	19	10	5	65
% over total	6.63%	28.13%	57.58%	66.67%	71.43%	20.63%
Population	45.999	116.661	261.172	287.018	685.137	1.395.987
% over total	9.83%	26.66%	56.74%	72.06%	69.41	50.74%
	Total municipalities of Galicia					
Number inhabitants	**<5.000**	**5.001-10.000**	**10.001-20.000**	**20.001-50.000**	**>50.000**	**Total**
Number Municipalities	196	64	33	15	7	315
Population	467.666	437.625	460.274	398.297	987.148	2.751.105

Source: Own elaboration from a survey made by Autonomous University of Madrid and the Survey on Facilities and Infrastructures.

Table 2 Descriptive statistics of the variables used in the empirical analysis

Variable	**Media**	**Desv. Standard**	**Mín.**	**Máx.**
TOTAL COST (€)	780,957.2	2,241,709	34,475.7	1.78e+07
OUTPUT (Tm)	29,142.16	35,355.95	1,046.4	160,650
PERSELECT*	0.23	0,11	0.06	0.59
FREC	6.28	1.61	2	7
TURIS	0.0013	0.0019	0.00002	0.012
PLANTS	0.06	0.24	0	1
WAGES	32.712,06	1.235,31	31.036	34.404
D^{PRIV}	0.64	0.48	0	1

*Municipalities with less than 50000 inhabitants

Source: Own elaboration from a survey made by the Autonomous University of Madrid and the Survey on Facilities and Infrastructures.

Table 3. Correlation matrix of the variables used in the empirical analysis

	COST	OUTPUT	FREC	TURIS	WAGES	PLANTS	D^{PRIV}
COST	1						
OUTPUT	0.50	1					
FREC	0.13	0.30	1				
TURIS	0.06	0.06	-0.15	1			
WAGES	-0.12	-0.44	0.04	-0.25	1		
PLANTS	0.06	-0.04	-0.02	-0.02	-0.08	1	
D^{PRIV}	0.18	0.18	0.23	0.06	0.28	0.06	1

Note: We exclude PERSELECT since information is not available for the municipalities in the sample.

Source: Own elaboration from a survey made by the Autonomous University of Madrid and the Survey on Facilities and Infrastructures.

Table 4. Results of estimates (OLS). Sample = All the municipalities with available information

Explanatory variables	Explanatory variable: LCT	Variance Inflation Factors (VIF)
LOUTPUT	0.88 (0.09)***	1.52
LPERSELECT	-	-
LFREC	0.43 (0.14)***	1.21
LTURIS	0.10 (0.05)**	1.28
LPLANTS	-0.42 (0.26)*	1.02
LWAGES	-2.37 (2.16)	1.28
D^{PRIV}	0.33 (0.17)*	1.49
INTERCEPT	29.89 (22.10)	-
N R^2 F (Joint Sign.) Test Ho: $\beta_1 \geq 1$	65 0,79 38.82*** 1.54	

Note 1: Standard errors in parentheses (robust to heteroscedasticity)
Note 2: Significance at 1% (***), 5% (**), 10% (*).

Table 5. Results of estimates (OLS). Sample = All the municipalities with available information with less than 50000 inhabitants

Explanatory variables	Explanatory variable: LCT	Variance Inflation Factors (VIF)
LOUTPUT	0.85 (0.07)***	1.51
LPERSELECT	-0.16 (0.13)	1.40
LFREC	0.39 (0.15)**	1.30
LTURIS	0.12 (0.05)***	1.22
LPLANTS	-0.53 (0.29)*	1.04
LWAGES	0.64 (1.80)	1.61
D^{PRIV}	0.20 (0.15)	1.48
INTERCEPT	-1.26 (18.67)	-
N R^2 F (Joint Sign) Test Ho: $\beta_1 \geq 1$	60 0.85 49.29*** 3.55**	

Note 1: Standard errors in parentheses (robust to heteroscedasticity)
Note 2: Significance at 1% (***), 5% (**), 10% (*).