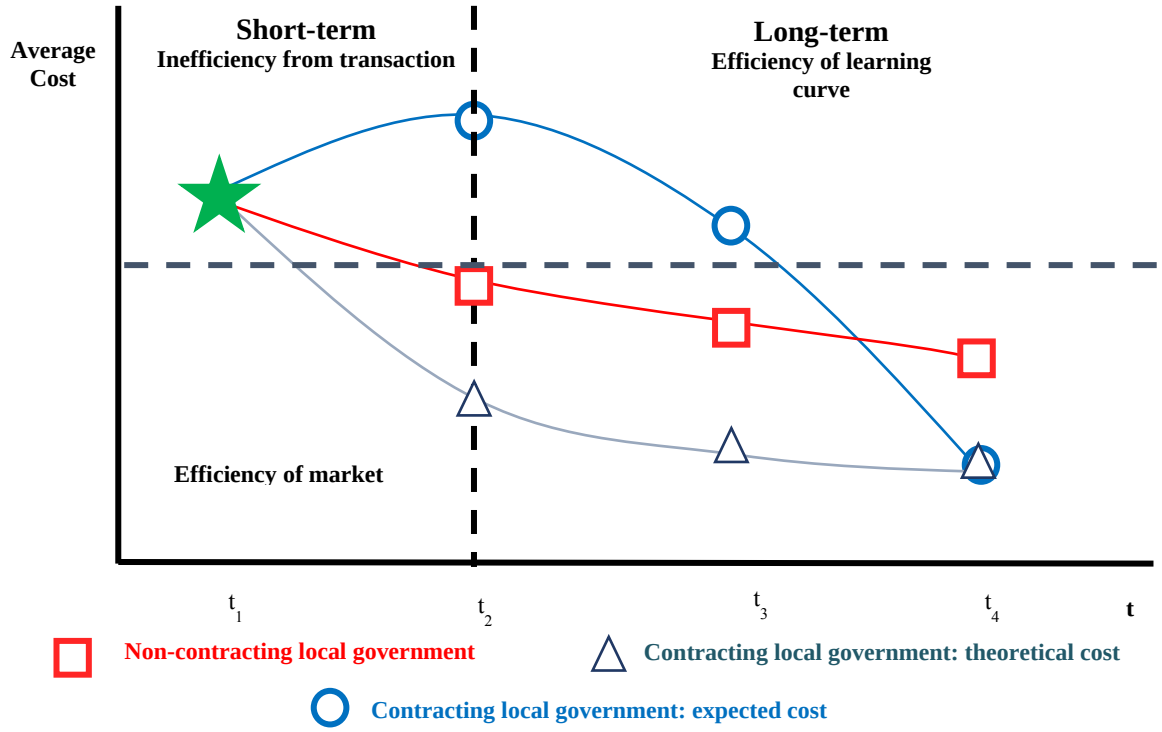
Appendix A

Fig. A1. Transaction costs and the learning effect when the service is contracted out[1]



Source: The author

Appendix B: Algorithm of the order-*m* methodology

Formally, the algorithm estimating the order-*m* efficiency coefficients considers for a specific level of input (x_0) and output (y_0), *m* random DMUs with output variables ($Y_1, \dots, Y_m$), drawn from the distribution of the output matrix *Y* observing the condition $Y_m \geq Y_0$. Therefore, and following Daraio and Simar (2007), the following four steps are applied:

1. For a given level of output (y_0), a random sample of size m is created with replacement among those y_{sm}, such that $y_{sm} \geq y_0$.

2. The efficiency coefficient $\tilde{\alpha}_s$ is estimated using this random sample.

3. Steps 1 and 2 are repeated B times, so that for each round an efficiency coefficient is estimated, with B efficiency coefficients $\tilde{\alpha}_S^b$ (b = 1; 2; ...; B).

4. Finally, the efficiency score is computed as a central value (the arithmetic mean) of the estimated B efficiency coefficients:[2]

$$\alpha_S^m = \frac{1}{B}\sum_{b=1}^{B} \tilde{\alpha}_S^b$$

Appendix C: Variables included in the computation of cost efficiency scores

Table C1 Variable definitions

Variable	Definition	Source
Total Cost	Municipal budget expenditure, obtained from the functional budget classification, *Category 442 – Refuse collection removal and street cleaning,* for each of the municipalities included in the sample. This classification has been used in several previous studies (Benito-López et al., 2011; Zafra-Gómez et al., 2013). Due to the implementation of a new classification system (O. EHA / 3565/2008, of 3 December), with respect to the year 2010 we used the equivalent, composed of *Category 162 – Waste collection, disposal and treatment* and *Category 163 – Street cleaning*.	Virtual Office of Local Government Financial Coordination of the Ministry of Public Administration and Treasury
Refuse collection tons	Annual production of waste, in tons/year.	Survey of Local Infrastructure and Equipment (EIEL), from the Ministry of Public Administration's website
Refuse collection tons*quality	Annual production of waste, in tons/year, corrected by the index of service quality.	
Containers	Number of containers recorded as installed on public roads in the municipalities, for each type of refuse collection.	

Source: The author, based on data supplied by the Virtual Office of Local Government Financial Coordination and on the Survey of Local Infrastructure and Equipment.

Table C2. Descriptive statistics: variables included in the computation of the cost efficiency scores						
Year	**Cost/Outputs**	**Mean**	**Median**	**Minimum**	**Maximum**	**Standard deviation**
2002	Total Cost	443565.5	224233.2	443.35	7753480	676405.1
	Refuse collection tons	26277.44	4410.985	9	6077887	309747.6
	Refuse collection tons*quality	52249.05	8748.1	18	1.22e+07	619512.8
	Containers	567.6114	367.5	0	19835	1097.068
2003	Total Cost	511258.2	254069.9	60.69	7914726	779541.7
	Refuse collection tons	26277.44	4410.985	9	6077887	309747.6
	Refuse collection tons*quality	52249.05	8748.1	18	1.22e+07	619512.8
	Containers	567.6114	367.5	0	19835	1097.068
2004	Total Cost	568652.6	274453.5	8264.53	8031755	844674.8
	Refuse collection tons	26277.44	4410.985	9	6077887	309747.6
	Refuse collection tons*quality	52249.05	8748.1	18	1.22e+07	619512.8
	Containers	567.6114	367.5	0	19835	1097.068
2005	Total Cost	639734.4	315227.1	3550	1.01e+07	965806.2
	Refuse collection tons	26277.44	4410.985	9	6077887	309747.6
	Refuse collection tons*quality	52249.05	8748.1	18	1.22e+07	619512.8
	Containers	567.6114	367.5	0	19835	1097.068
2006	Total Cost	716935	345860.8	912.8	8515038	1014044
	Refuse collection tons	19129.09	4119.9	31.1	1941128	116737.2
	Refuse collection tons*quality	37969.36	8163.038	56.6	3882257	233027.1
	Containers	547.9408	389.5	0	6611	600.0957
2007	Total Cost	769710.7	397842	583.51	1.00e+07	1024811
	Refuse collection tons	19129.09	4119.9	31.1	1941128	116737.2
	Refuse collection tons*quality	37969.36	8163.038	56.6	3882257	233027.1
	Containers	547.9408	389.5	0	6611	600.0957
2008	Total Cost	838656.5	449418.8	2598.04	9082999	1095121
	Refuse collection tons	19129.09	4119.9	31.1	1941128	116737.2
	Refuse collection tons*quality	37969.36	8163.038	56.6	3882257	233027.1
	Containers	547.9408	389.5	0	6611	600.0957
2009	Total Cost	922979.4	444970.3	300	1.15e+07	1271402
	Refuse collection tons	9584.429	4305.005	126.53	786045.3	43818.79
	Refuse collection tons*quality	18854.65	8525.306	165.03	1541915	86376.17
	Containers	546.1588	406.5	9	3526	493.738
2010	Total Cost	984479.5	445025.9	868.85	1.72e+07	1579779
	Refuse collection tons	9875.644	3925.95	202.5	786180.9	47344.01
	Refuse collection tons*quality	19489.15	7822.269	405	1542186	93524.58
	Containers	583.9645	426	9	3476	533.0506

Appendix D. Variation in cost efficiency

Table D1 Annual number of new contractors[3]

Year	2003	2004	2005	2006	2007	2008	2009	2010	Total
New contractors	8	7	8	11	6	15	23	17	95
Contracting out rate[a]	1.90	1.69	1.97	2.76	1.55	3.93	6.27	4.94	

[a] The contracting-out rate is defined as the percentage of new contractors with respect to the number of non-contractors in the previous year.

Table D2 Descriptive statistics: variation in cost efficiency

Year	Municipality	Obs.	Mean	Minimum	Maximum	SD
2002	Non-contracting	422	0	0	0	0
	Contracting	-	-	-	-	-
2003	Non-contracting	414	-.0107683	-1.560381	2.057847	.1815395
	Contracting	8	-.0144451	-.084164	.0011151	.029346
2004	Non-contracting	407	-.0154334	-2.057956	.7717245	.1319294
	Contracting	15	-.0250306	-.1592655	.0000214	.049474
2005	Non-contracting	399	-.0109131	-.9470752	.220079	.0672379
	Contracting	23	-.0034925	-.0389816	.0072776	.0091634
2006	Non-contracting	388	.0078489	-.7494582	.9997973	.1583372
	Contracting	34	.0013103	-.304226	.1990875	.0748855
2007	Non-contracting	382	-.003496	-.30033	.9130174	.0676135
	Contracting	40	-.0058664	-.0635999	.000993	.0143546
2008	Non-contracting	367	-.0076713	-.8927622	.7475233	.0924674
	Contracting	55	-.0071185	-.4427732	.1256962	.0637509
2009	Non-contracting	344	-.0066874	-.9223195	1.005759	.1377441
	Contracting	78	-.0264867	-.9635553	.1271822	.1296859
2010	Non-contracting	327	.0170505	-.8559671	1.7242	.2043455
	Contracting	95	.0064636	-.4961455	.5881901	.1024709

Appendix E: Factors determining the contracting out of local public services

Many studies have been conducted to identify factors that influence the decision to contract out local public services (FERRIS, 1986; BEL and FAGEDA, 2007; GONZÁLEZ-GÓMEZ and GUARDIOLA, 2008; WARNER and HEFETZ, 2008; ZAFRA-GÓMEZ et al., 2015).[4] Following existing literature on contracting out the waste collection service, the model specified below includes the efficiency recorded prior to contracting out ($\alpha_{S,it-1}^{m}$), the variables measuring municipal fiscal stress, the political and socioeconomic factors facing the local government and the effect of the economic crisis (Great Recession).

$$P(D_t = 1) = \Phi\left\{\begin{matrix}\alpha_{S,it-1}^{m}, cash_{it-1}, taxincome_{it-1}, budgetresult_{it-1}, transfer_{it-1}, \\ polsign_{it-1}, polstrength_{it-1}, GR_t, lpop_{it-1}, tourism_{it-1}, popcentre_{it-1}\end{matrix}\right\} \quad (6)^{5}$$

where Φ(.) is the normal cumulative distribution function.

Table E1 Definition of variables included in the probit model

Variables	References[6]	Expected sign	Definition	Source
Contracting out		(Dependent variable)	Dummy variable taking value 1 if at the end of the period 2002-2010 the local government has contracted out the refuse collection service and 0 otherwise	The authors, based on the Survey of Infrastructure and Equipment (EIEL, from Ministry of Public Administration and Treasury), Virtual Office of Local Government Financial Coordination of the Ministry of Public Administration and Treasury, Official Provincial Gazettes (BOP) and municipal web pages
Cost efficiency ($\alpha_{S,it-1}^{m}$)[7]		-	Ratio that measures the relationship between municipal spending in relation to the outputs achieved (score obtained through order-*m* methodology)	Municipal spending: Virtual Office of Local Government Financial Coordination of the Ministry of Public Administration and Treasury Output variables: Survey of Local Infrastructure and Equipment (EIEL), from the Ministry of Public Administration's website
Financial Stress	(Savas, 2000; Greene, 2002)			
Cash Index		+/-	Percentage of cash over liquidated obligations	Virtual Office of Local Government Financial Coordination of the
Taxable value		+/-	Fiscal receivables	

divided by Financial Charge Index			divided by annual amortisation payment – interest and principal	Ministry of Public Administration and Treasury
Non-financial Current Budgetary Result Index (*Budget Result Index*)		+/-	Current budgetary payables and non-financial capital budgetary payables divided by non-financial current budgetary receivables and non-financial capital budgetary receivables	
Independence Index		+/-	Percentage of total income excluding transfers received over total expenditure	
Political factors				
Political Orientation	(Bel and Fageda, 2007)	-	Dummy variable that takes the value 0 if the municipal government has a conservative ideology and 1 if it is left-leaning	The authors, based on the website of the Ministry of the Interior.
Political Strength	(Salinas and Alvarez, 2002; León et al., 2010; Rodrigues et al., 2012)	+/-	Dummy variable that takes the value 0 if the municipal government shares power with other parties and 1 if it has an absolute majority	
Great Recession	(Funkhouser, 2012)	+	Dummy variable that takes the value 1 for the years of the Great Recession (2008-2010) and 0 for the other years of the period considered	Elaborated by the authors
Population	(Bel et al., 2010)	+	Logarithm of the number of inhabitants corresponding to each local government for each year of the period 2002 and 2010	National Institute of Statistics (INE) and the Economic Yearbook of 'La Caixa'
Tourism Index	(Bel and Mur, 2009)	+	Index that measure the tourism-oriented activities of the municipality	The Economic Yearbook of 'La Caixa'.
Population centres	(Bel and Miralles, 2003; Bel et al., 2010)	+	Number of population units within the municipal area	Continuous register. National Institute of Statistics (INE)

Table E2 Descriptive statistics of the variables included in the probit model				
Variable	**Mean**	**Minimum**	**Maximum**	**Std. Deviation**
Cost efficiency	.0768693	.0000373	2.058116	.19083
Cash Index	3.859339	-192.8108	1176.286	32.47208
Taxable value over financial charge Index	22.62513	.2498085	14739.43	268.2594
Budget Result Index	1.023976	.4269567	3.292641	.1721207
Independence Index	.5783543	.1213181	2.765167	.2075042
Political Orientation	.6288507	0	1	.4831839
Political Strength	.5859005	0	1	.4926388
Great Recession	.25	0	1	.4330768
Population	9.069115	6.96602	11.0469	.7712259
Tourism Index	1.973702	0	115.8107	7.221282
Population centres	12.39336	0	224	25.28506

Table E3 Probit estimates to calculate the propensity score (probability of a municipality becoming a new contractor)		
Variables	**Marginal effect**	**Standard error**
Cost efficiency $_{t-1}$	-0.0008	(0.0010)
Cash Index $_{t-1}$	-0.0002	(0.0003)
Taxable value over Financial Charge Index$_{t-1}$	-0.0001	(0.0001)
Budget Result Index $_{t-1}$	-0.0019	(0.0168)
Independence Index $_{t-1}$	0.0330**	(0.0148)
Political Orientation $_{t-1}$	-0.0090*	(0.0057)
Political Strength $_{t-1}$	-0.0073	(0.0055)
Great Recession $_{t-1}$	0.0326***	(0.0088)
Population (lpop) $_{t-1}$	0.0122***	(0.0039)
Tourism Index $_{t-1}$	0.0004*	(0.0003)
Population centres $_{t-1}$	-0.0001	(0.0001)
Observations	3,123	

Standard errors in parentheses.* Significant at 10 %, ** significant at 5 %, and *** significant at 1%

Appendix F: Quality of the matching

Various approaches may be taken to evaluate whether the matching procedure employed is capable of balancing the distribution of the relevant variables both for new contractors and for matched non-contractors, when one variable influences the propensity score.

Following Sianesi (2004), Table 3.1 shows a pseudo R^2 test and a joint significance test, used as matching quality indicators. Sianesi (2004) suggested the propensity score should be re-estimated on the matched sample, that is, only on new contractors and matched non-contractors, and that the probit pseudo R^2 should be compared before and after the matching.

The probit pseudo R^2 value indicates how well the regressors X explain the probability of a municipality initiating contracting out. After matching, there should be no systematic differences in the distribution of the regressors between the two groups, and therefore the pseudo R^2 value should be fairly low for the matched sample. As reported in Table A.1, we obtained small values for the pseudo R^2 after matching. Sianesi (2004) also proposed that an F test should be conducted on the joint significance of all the probit regressors before and after matching. The interpretation of this test is that the joint significance of the regressors should be rejected after matching but not before. We obtained this result for the different time periods considered.

Another indicator used to assess the distance in marginal distributions of the X variables is the median bias, as suggested by Rosenbaum and Rubin (1985). Median bias refers to the median absolute standardised bias before and after matching. The median is calculated over all regressors. Following Rosenbaum and Rubin (1985), for a given regressor the standardised difference before matching is the difference of the sample means between new contractors and non-contractors as a percentage of the square root of the average of the sample variances from the two sub-samples (new contractors and non-contractors, respectively). The standardised difference after matching is calculated analogously, using the corresponding values for the matched samples. A potential problem in this approach to interpreting the standardised bias is that there is no clear indicator of the success of the matching procedure. In our study, a substantial reduction was obtained in the standardised bias, which seems to be consistent with the results obtained in previous empirical studies.

Table F.1: Quality of the matching		
	Before	After
(a) Median bias in the probit regression		
t -1/*t*	21.010	2.218
t /*t* +1	20.397	5.285
t + 1/*t* + 2	21.894	13.305
t + 2/*t* + 3	22.782	10.277
(b) Probit pseudo R^2		
t -1/*t*	0.074	0.008
t /*t* +1	0.066	0.025
t + 1/*t* + 2	0.073	0.043
t + 2/*t* + 3	0.068	0.057
(c) $p > \chi^2$ (LR test of joint significance of coefficients in the probit regression)		
t -1/*t*	0.000	0.996
t /*t* +1	0.000	0.870
t + 1/*t* + 2	0.000	0.413
t + 2/*t* + 3	0.002	0.878

(a) Median bias refers to the median absolute standardised bias before and after matching.
(b) Probit pseudo R^2 for contracting starters on covariates before matching and in matched samples (after matching).
(c) $p > \chi^2$ is the p-value of the likelihood-ratio test after matching. This is a test of the hypothesis that the regressors are jointly insignificant, i.e., that they are well balanced in the two samples.

[1] This figure shows the evolution of theoretical cost efficiency for services with high transaction costs. Such services are often characterised by high asset specificity and low measurability (BROWN and POTOSKI, 2005) and by the long-term nature of the contract.

[2] Note that $\tilde{\alpha}_S^b$ depends on the level of m: the higher the value of m, the more observations are considered in the estimation and the more units will meet the condition $y_{sm} \geq y_0$. Therefore, when $m \to \infty$ the order-*m* efficiency score will converge with the FDH scores. In order to determine the value of *m*, the efficiency scores are computed for different values of *m,* as this represents the value at which the percentage of superefficient DMUs decreases marginally with an increase in *m* (DARAIO and SIMAR, 2005). After performing various estimations (*m* = 100, 200 …500), it is observed that the results were very stable from *m*=300. Additionally, to increase the quality of the estimation, the order-*m* methodology was applied assuming $B = 2{,}000$ (De Witte and Geys, 2013). [DEWITTE K. and GEYS B. (2013) Citizen coproduction and efficient public good provision: theory and evidence from local public libraries, *European Journal of Operational Research* 224, 592–602; DARAIO, C. and SIMAR, L. (2005) Introducing environmental variables in nonparametric frontier models: a probabilistic approach, *Journal of Productivity Analysis* 24(1), 93–121.]

[3] The municipalities were classified as contractors or non-contractors on the basis of the information supplied by the Virtual Office of Local Government Financial Coordination of the Ministry of Public Administration and Treasury, and according to the information published in Official Provincial Gazettes (BOP) and in municipal web pages.

[4] BEL, G. and FAGEDA, X. (2007) Why do local governments privatise public services? A survey of empirical studies, *Local Government Studies* 33(4), 517–34.

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GONZÁLEZ-GÓMEZ, F. and GUARDIOLA, J. (2008) A Duration Model for the estimation of the contracting out of urban water management in southern Spain, *Urban Affairs Review* 44(6), 886–906.

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[5] This probit model also includes dummy variables for each year of the sample, in order to control for the year in which local governments start to contract out the refuse collection service.

[6] BEL, G., FAGEDA, X. and MUR, M. (2010) ¿Por qué se privatizan servicios en los municipios (pequeños)? Evidencia empírica sobre residuos sólidos y agua, *Hacienda Pública Española/ Revista de Economía Pública* 192, 33-58.

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SALINAS, J. and ÁLVAREZ, S. (2002) La efectividad de los límites al endeudamiento autonómico: una perspectiva de teoría de la elección pública. Subdirección General de Estudios Presupuestarios y de Gasto Público. Instituto de Estudios Fiscales.

SAVAS, E.S. (2000) Privatization and Public-Private Partnerships. New York: Chatham House Publishers.

[7] We include this variable in order to assess whether the cost efficiency obtained in the previous year would affect the likelihood of the refuse collection service being contracted out. A negative relation is expected, as the decrease in cost efficiency would favour the contracting out decision.