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MARKET STRUCTURE OF URBAN SOLID WASTE. DIFFERENT MODELS, DIFFERENT RESULTS

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Abstract

The urban waste services in Portugal have been, historically, provided together with other services, such as water services. Despite the lack of discussion on this subject in the literature, some questions have been raised about the gains, in terms of efficiency, of this policy. Following a recent and robust partial nonparametric frontier model, based on order-α, we intend to evaluate the presence of economies of scope and scale in the Portuguese waste sector. The results show the absence of economies of scope between waste and water (and wastewater) services. In addition, we identify the presence of economies of scale in smaller municipalities, suggesting that cooperation (or amalgamation) between these municipalities could lead to cost savings. These outcomes might be useful for policy and decision-makers in further reforms.

Keywords: Economies of scale; Economies of scope; Efficiency; Partial frontier methods; Waste sector

MARKET STRUCTURE OF URBAN SOLID WASTE. DIFFERENT MODELS, DIFFERENT RESULTS

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1. Introduction

In Portugal, the provision of urban waste services has been strongly connected with the water and wastewater services provision. The reasons for this circumstance might be explained by historical reasons since both are local public services under the responsibility of municipalities; however, there is also an important aspect related to the way of charging the waste service. In fact, the water bill continues to be the only effective way of charging it (Pássaro, 2003). Besides these reasons, the waste service (mainly the refuse collection), as well as the water services, remain, generally, being provided by the same operator.

This circumstance raises diverse questions about the efficiency of providing waste and water services together. From an economic perspective, one can question if there are savings through a lower average cost, for an operator by providing those services together or a lower cost by providing them separately (Panzar and Willig, 1975). These savings are known was economies of scope. A particular case of scope economies concerns the vertical integration of elements of the supply chain in urban waste (e. g. refuse collection, transfer stations, transportation, treatment and disposal and recycling). The savings associated with economies of scope might be related to the synergies resulting from the joint provision or from sharing fixed

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costs, while the absence of economies of scope can be associated with more specialization in the provision of different services/goods. In the waste sector the non-abundant literature has been more focused on economies of scale (Stevens, 1978; Tickner and McDavid, 1986; Antoniolli and Filippini, 2002) while economies of scope have been scarcely discussed. In fact, to our best knowledge, only Callan and Thomas (2001) analysed this aspect, although their work are just focused on two components of the waste sector (disposal and recycling services), by means of a multioutput cost structure analysis based on a parametric approach. As expected, they identified overall scope economies between these two markets.

The present paper provides diverse contributions for the literature, not only related to the waste sector, but also in a methodological perspective. It develops and applies a new non-parametric approach, based on partial frontier methods, to evaluate the existence of economies of scope (Carvalho and Marques, 2010). These recent methods are more robust and have nice statistical and economical properties and meanings (Daraio and Simar, 2007). Moreover, such study is considerably important from a policy point-of-view, since whatever economies of scope are identified, the conclusions and financial incentives taken from their existence might be followed by other countries with a comparable organization and similar characteristics in the waste market.

After this introduction, a brief description of the Portuguese waste market structure is carried out in section 2. Section 3 summarizes the methodology applied and section 4 presents the case-study and the results for the 'wholesale' and 'retail' waste markets. Finally, the main conclusions are drawn in the last section.

2. MARKET STRUCTURE AND REGULATION

2.1 Introduction

The Portuguese waste sector, in line with Massarutto (2007), might be stratified in three distinct markets, regardless of its ownership and of possibly being provided

by the same operator. The waste sector can be classified into primary, secondary and tertiary markets (Marques and Simões, 2009). In the Portuguese waste sector, the primary market is related to the 'retail' service, i.e. collection and street cleaning, while the secondary market is inherently associated with the 'wholesale' services that comprise the urban waste treatment, landfill[2] or other appropriate treatment facility, and the waste transportation between the transfer stations (when they exist) and their facilities. Transfer stations also belong to the 'wholesale' market. Finally, the tertiary market concerns the recycling, including its diverse branches, such as, packaging, batteries, tyres, electric material, among others.

2.2 Ownership

The private sector has a short history in the Portuguese public services, and in the waste services in particular. In fact, only after a reform, in 1993, was private capital allowed in these services. After that, we have observed a proliferation of the private sector, mainly in the last decade, but mostly in the refuse collection and the urban cleaning (through short-term contracts).

Table 1 shows the range of possible management arrangements for the Portuguese waste sector, even though some of them may not exist yet (ERSAR, 2010).

Table 1 - Management models in the Portuguese waste sector

	Management models of State ownership	
	Operator	Partnership
Direct Management	State	No one
Delegated	Public company	No one
Concession	Regional public company	Public-Public[3]
	Management models of municipal ownership	

[2] Despite the efforts of the European Commission to minimize this tendency, this one remains the type of treatment mostly used.

[3] This kind of partnerships is established between State and municipalities, with the possible trend to evolve to Public-Private Partnerships (State, municipalities and private companies).

	Operator	Partnership
Direct Management	Municipality	No one
	Semi-autonomous operators	No one
	Municipal associations	Public-Public (several municipalities)
Delegated	Municipal (or regional) companies	No one or Public-Private
	Local corporate entities	No one or Public-Private
	Parishes and users associations	Public-Public (several municipalities)
Concession	Municipal companies	Public-Private (municipalities and private companies)

2.2 Organization

2.2.1 'Wholesale' market

In Portugal, the 'wholesale' sector comprises 32 operators, of which 29 are in the mainland and three in the Portuguese islands. Regarding the mainland, 17 of them are concession arrangements from which 14 are controlled by the State[4] and 3 by private operators. The remaining 12 are intermunicipal systems from which half of them became public-private partnerships (PPPs). As far as the islands are concerned, 2 of them are intermunicipal systems and 1 a semi-autonomous operator. Table 2 summarizes the waste market structure of the 'wholesale' market in Portugal.

[4] The State has its branch on the environmental field (water, wastewater and waste) through the Empresa Geral de Fomento (EGF), the sub-holding of Águas de Portugal (State company).

Table 2 'Wholesale' waste operators in the Portugal until 2010

	Operators	Municipalities	Population (10^3)	
Municipal semi-autonomous operators	1	2	56	(0.5%)
Multimunicipal concessionaires	15	160	5,774	(56.2%)
Municipal concessionaries	2	19	258	(2.5%)
Intermunicipal associations and services	6	41	1,931	(18.8%)
Intermunicipal companies	8	74	2,264	(22.0%)
TOTAL	**32**	**296**	**10,283**	

Figure 1 shows the Portuguese 'wholesale' waste services per management model.

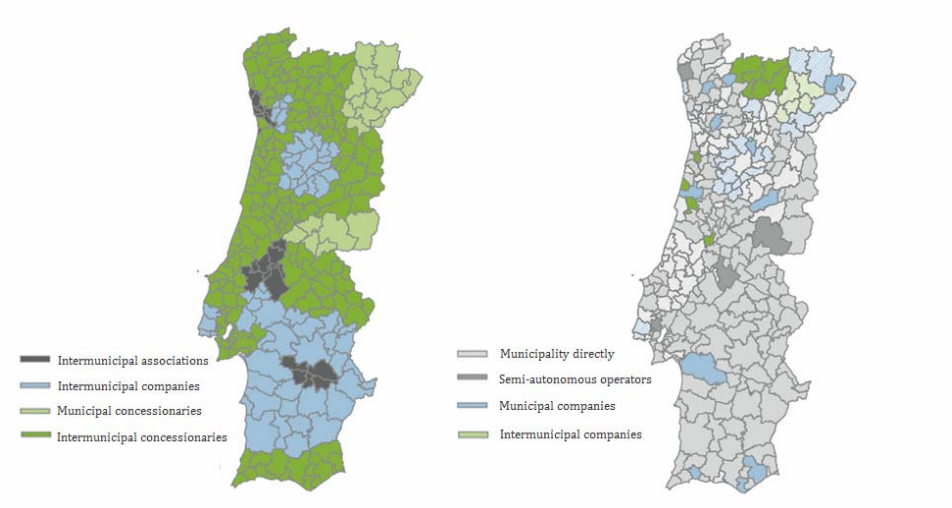


Figure 1 – 'Wholesale' and 'retail' operators per management model, respectively

2.2.2 'Retail' market

Regarding the 'retail' market, despite the increasing trend of private sector participation, the services of refuse collection and urban cleaning are still being commonly provided directly by the municipality, which represents more than 76%, in terms of population served. However, great part of them sees in

outsourcing an efficient way to be followed, awarding short-term contracts (1 to 5 years). Semi-autonomous operators embrace other management model (very popular in Portugal). They are endowed with financial and administrative autonomy and correspond to about 5% of the 'retail' market. There are also corporatized municipal companies (covering 12% of the population), comprising only the municipality as shareholder (66%) or mixed (PPs) capital (34%). Nevertheless, in both of them the municipality assumes the role of major shareholder. There are also a few examples where the "wholesale" operator provides the refuse collection service.

Considering all types of management of the Portuguese 'retail' market, there are more than 250 waste operators, characterised by different institutional frameworks, ranging from regional companies to the municipality directly managed. Table 3 presents the waste market structure of the 'retail' market in Portugal.

Table 3 – 'Retail' waste operators in the Portugal until 2010

	Operators	Population (10^3)	
Directly by municipalities	245	7,904	76.5%
Semi-autonomous operators	7	562	5.4%
Municipal companies	16	1,262	12.2%
Intermunicipal operators	6	607	5.9%
TOTAL	**274**	**10,335**	

2.2.3 Tertiary market

In the tertiary market (recycling and reselling) the main and most recognized entity is SPV, which is in charge of the selective collection and simultaneously it is responsible for the take-back of waste likely to be recycled. Currently, there are also other organizations responsible for other branches, such as Amb3E for electronic equipment, Valorpneu for used tires and Ecopilhas for used batteries, among others.

2.3 Integration and other services provision

In Portugal, the waste services, with particular exceptions, are not vertically integrated, i.e. the 'wholesale' and 'retail' markets are generally provided separately, i.e. by a different operator.

Regarding the provision of other services, such as the drinking water supply, it is hardly observed in the 'wholesale' market, while in the 'retail' market this circumstance is quite more common. Table 4 presents the operators that provide refuse collection and refuse collection along with drinking water supply, per type of management. In addition, it also shows the degree of vertical integration.

2.4 Regulation

The Portuguese waste sector has undergone, in the past years, several reforms in its different fields. In particular, the implementation of a waste sector regulator, the Institute for the Regulation of Water and Waste (IRAR, renamed recently by Water and Waste Services Regulatory Authority – hereafter, ERSAR) is the most notable one. The creation of this regulator, in 1997, which was atypical in Europe was a response to an unfavourable context that characterized the waste sector at the time, namely through the growing tendency for waste production, the need to provide adequate disposal, the tariffs far below the current service costs, the increasing private sector participation in a deregulated environment, and the importance that the waste sector has gained in the state budget (Simões et al., 2010).

Table 4 – Operators in charge of the 'retail' market in the Portugal until 2010

	Waste	Population (10^3)		Waste and Water	Population (10^3)	
Directly by municipalities	26	1.798	(17.4%)	219	6.106	(59.1%)
Semi-autonomous operators	2	114	(1.1%)	5	448	(4.3%)
Municipal companies	6	755	(7.3%)	10	507	(4.9%)
Intermunicipal operators	6	607	(5.9%)	0	0	(0.0%)
TOTAL	**40**	**3,274**	(31.7 %)	234	7,061	(68.3%)
Vertical integration utilities	7	643	(6.2 %)	0	0	(0.0%)
Without vertical integration	267	9,692	(93.8%)	0	0	(0.0%)
TOTAL	**274**	10,335	(100.0%)	0	0	(0.0%)

The strategy adopted by IRAR (ERSAR) has consisted in the sunshine regulatory model. It includes mainly the public display and regular comparison (benchmarking) of a set of 20 performance indicators and has become a powerful and effective tool to achieve its main objectives, such as assuring the quality of the services provided or supervising and guaranteeing the balance and sustainability of the sector, under the terms of its statutes and the law (Marques and Simões, 2008). ERSAR applies sunshine regulation both to 'retail' and 'wholesale' companies, which is displayed by a colour (traffic light) system, according to the result achieved. Besides characterizing the evolution of each performance indicator and making recommendations, which the regulator sees as useful for the operators to overcome their weaknesses, ERSAR defines targets individually to which the colour (red, yellow, green) is attributed, according to the distance from the corresponding best practice target (non-satisfactory, satisfactory or good). ERSAR also has economic regulatory functions but only over the 'wholesale' companies that are subject to a rate of return regulation with rules defined by the national law (e.g. capital cost).

3. COMPUTING SCALE AND SCOPE ECONONOMIES

To evaluate the existence of scale and scope economies, the literature has relied essentially on the parametric methodologies. However, this study uses nonparametric methodologies, since they present several advantages over the parametric ones. In particular, the nonparametric methods do not require so many *a priori* assumptions for the specification of the production function. They are conservative, deal easily with multiple inputs and outputs and might not involve information relative to input or output prices.

Furthermore, this study computes the latest and most robust nonparametric methods, known as partial frontier methods which have even more advantages over the traditional full frontier methods (such as Data Envelopment Analysis - DEA and Free Disposal Hull - FDH). These methods only use part of the sample (for more details on partial and full frontier methods, see Fried et al., 2008) to determine efficiency scores, therefore being less sensitive to extreme data and outliers. In addition, these methods, unlike the traditional full frontier methods, do not face the problem of the 'curse of dimensionality' and allow for relevant statistical features and interesting econometric interpretations (see Daraio and Simar, 2007).

In this paper, we apply the order-α method, instead of the order-m, because it is the most attractive partial frontier nonparametric method. The order-α method is more intuitive with respect to the amount (probability 1-α) of observations that are above the frontier and and it is less sensitive to extreme data (see Daouia and Simar, 2007). In our model specification we adopted an input orientation because the observations under study (waste, water and wastewater operators) aim to rationalize the quantity of inputs for a given level of outputs (considered constant).

Regarding the evaluation of scope economies, we used a recent proposed approach of Carvalho and Marques (2010), based on the order-α methodology. Scope economies are related to savings originated from joint production of goods or services (Panzar and Willig, 1981). So, there are scope economies when the costs

of production of two or more goods produced together are lower than the costs of producing them separately (Baumol et al., 1988). Conversely, there are diseconomies of scope.

This methodology allows for the comparison of the joint efficient production frontier and the separate efficient production frontier, and so estimates scope economies. If the joint production is more efficient than the separate production, that is, if the efficient frontier of the joint production dominates mostly the efficient frontier of the separate production there are economies of scope, otherwise there will be diseconomies of scope.

In this study, we looked for scope economies in the 'retail' market and in the 'wholesale' market. Regarding the 'retail' market, we estimated the efficient frontier of the group of operators that provides various services in addition to waste services (Uw) (efficient frontier of joint production - F_{WsUw}), such as water supply and wastewater services (Ws), and we estimated the efficient frontier of the group of operators that provides the waste service separately from other services (efficient frontier of separate production - $F_{Ws\ +Uw}$). This last group of operators is built by creating fictitious operators (Ws + Uw) combining the real Ws operators with the Uw operators existing in the waste sector in Portugal, summing up their corresponding inputs and outputs.

The presence of scope economies can be identified by assessing the dominance of that frontier over the other one. For this purpose, we have determined for each multiproduct operator (WsUw) the efficiencies relative to the frontier of its own group (F_{WsUw}) (θ) and the super-efficiencies relative to the frontier of the fictitious operators Ws+Uw ($F_{Ws\ +Uw}$) (θ_j) and compared them to the ratio:

$$\hat{\theta} = \theta_j / \theta \qquad (6)$$

Thus, the multiproduct operators with a ratio $\hat{\theta} > 1$ present economies of scope and the multiproduct operators with a ratio $\hat{\theta} < 1$ exhibit diseconomies of scope.

4. CASE STUDY

4.1 Sample and model specification

4.1.1 'Retail market'

In this analysis, we investigated the existence of economies of scope between the waste collection service and water services (including drinking water supply and wastewater) and also the possible presence of economies of scale in this market. The sample is made up of 233 operators and data are relative to the year 2008, covering about 80% of the Portuguese population. The sample is composed mostly of operators that provide just the urban waste service (Uw) (77%) and by a smaller number of operators that provide the water services (Ws operators), about 17% and operators that provide the two services (water services and urban waste service, WsUw operators), with about 6%. Figure 2 shows the sample used.

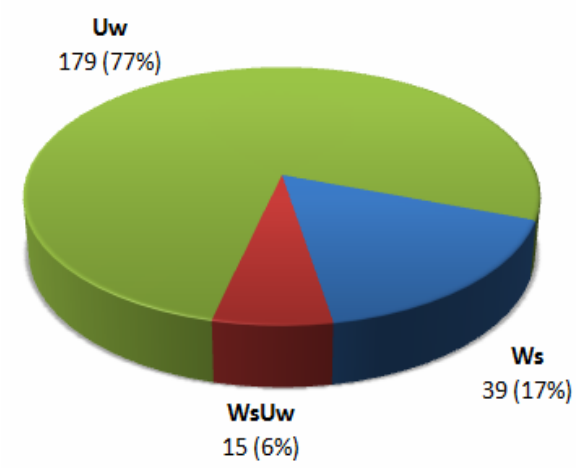


Figure 2 - Operators analysed in the 'retail' market

In the search for economies of scope in the 'retail' market, we selected labour cost and other operational costs as input variables and volume of water delivered, volume of wastewater treated and tonnage of urban waste collected as outputs.

For the study of scale economies in the 'retail' market, we have investigated only the operators that provide the urban waste service (Uw operators). We have considered two distinct models. In the first model (Model I) we selected merely

financial inputs such as labour cost and other operational costs, and as output the tonnage of urban waste collected. In the second model (Model II) we used some physical inputs rather than just financial inputs. We selected the following inputs: number of employees, number of vehicles and other operational costs and as output the tonnage of urban waste collected. Table 5 provides some statistics of these input and output variables of the sample.

Table 5 – Statistical features of data relative to water services (Ws), water and urban waste services (Wsw) and urban waste services (Uw) in the 'retail' market

STATISTICS	INPUTS				OUTPUTS		
	Labour cost	Other costs	Staff	Vehicles	Water delivered	Wastewater	Urban waste
	(10^3€)	(10^3€)	(units)	(units)	(10^3m^3)	(10^3m^3)	(ton)
Water services							
Average	2,967	6,545	---	---	5,998	2,269	0
St. Deviation	3,357	7,111	---	---	5,974	2,536	0
Minimum	77	489	---	---	307	70	0
Maximum	13,290	30,085	---	---	23,715	11,528	0
Median	1,777	3,870	---	---	3,605	1,200	0
Water and waste services							
Average	4,296	6,943	---	---	4,688	1,654	30,472
St. Deviation	4,698	7,661	---	---	4,697	1,747	28,732
Minimum	484	456	---	---	334	87	3,463
Maximum	19,447	32,482	---	---	19,778	5,849	125,809
Median	2,930	5,386	---	---	3,669	834	21,696
Waste services							
Average	611	561	33	8	0	0	17,915
St. Deviation	1,729	1,240	91	15	0	0	30,773
Minimum	32	4	3	1	0	0	380
Maximum	18,966	11,227	976	153	0	0	275,469
Median	194	137	12	3	0	0	7,158

4.1.2 'Wholesale market'

Concerning this market, we also analysed the presence of scope economies and scale economies. Here the sample is made up of 42 operators for the period between 2002 and 2008, covering the entire Portuguese population. Also, this sample is composed mostly of operators that provide just the urban waste service (Uw) and in smaller numbers, operators that provide other services such as water supply (Ws) and wastewater collection and treatment wastewater (Ww), as represented in Figure 3.

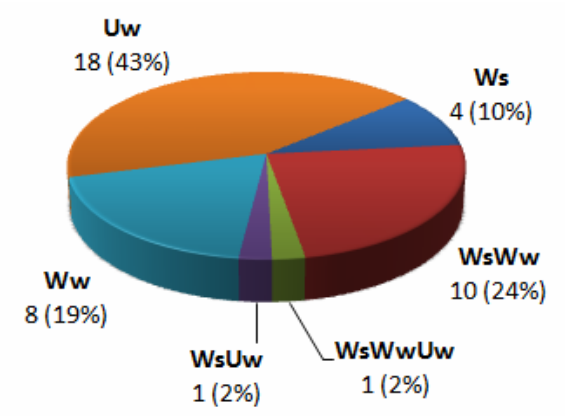


Figure 3 - Operators analysed in the 'wholesale' market

To investigate scope economies in the 'wholesale' market, we selected staff, capital costs (CAPEX) and other operational costs as inputs and volume of water delivered, volume of wastewater treated and the amounts of treated and recycled urban waste as outputs. Table 6 provides some statistics of these inputs and outputs for the operators analysed.

Table 6 – Statistical features of data of water services (Ws), water and wastewater services (WsWw), water, wastewater and waste services (WsWwUw), water and waste services (WsUw), wastewater services (Ww) and waste services (Uw) in the 'wholesale' market

STATISTICS	INPUTS					OUTPUTS		
	Staff	Other costs	CAPEX	Water delivered	Wastewater	Waste treated	Waste recycled	Urban waste
	(units)	(10^3€)	(10^3€)	(10^3m^3)	(10^3m^3)	(ton)	(ton)	(ton)
Water services								
Average	74	6,469	10,901	49,780	0	---	---	0
St. Deviation	50	4,868	8,711	43,305	0	---	---	0
Minimum	10	1,369	708	8,024	0	---	---	0
Maximum	145	13,820	23,512	114,043	0	---	---	0
Median	68	4,355	8,960	29,005	0	---	---	0
Water and wastewater services								
Average	71	5,407	6,127	11,926	6,468	---	---	0
St. Deviation	46	5,393	5,690	18,167	7,444	---	---	0
Minimum	15	407	299	286	3	---	---	0
Maximum	185	23,186	23,190	69,217	38,798	---	---	0
Median	58	3,299	4,756	5,043	4,002	---	---	0
Waste, water and wastewater services								
Average	138	5,342	12,489	12,230	5,116	---	---	76,623
St. Deviation	12	879	6,193	1,846	2,015	---	---	4,681
Minimum	121	3,939	5,460	9,069	3,527	---	---	70,707
Maximum	151	6,635	21,728	14,100	8,539	---	---	81,704
Median	140	5,272	11,152	12,447	4,381	---	---	77,020
Waste and water services								
Average	23	572	527	1,143	0	---	---	14,379
St. Deviation	2	100	158	147	0	---	---	503
Minimum	21	445	174	901	0	---	---	13,824
Maximum	26	729	640	1,297	0	---	---	15,001
Median	23	582	570	1,170	0	---	---	14,496
Wastewater services								
Average	69	4,341	6,845	0	29,429	---	---	0
St. Deviation	51	3,012	5,878	0	27,873	---	---	0
Minimum	9	262	63	0	353	---	---	0
Maximum	199	13,750	17,802	0	87,847	---	---	0
Median	47	4,422	5,227	0	17,479	---	---	0
Waste services								
Average	91	3,049	3,614	0	0	185,399	9,111	211,050
St. Deviation	77	4,079	4,543	0	0	204,885	11,910	220,779
Minimum	14	341	143	0	0	13,131	0	30,175
Maximum	265	20,069	22,560	0	0	786,405	64,392	838,848
Median	61	1,434	1,925	0	0	112,947	4,723	125,425

Finally, to evaluate scale economies in the 'wholesale' market, we have studied only the operators in charge of the waste service (Uw operators). The inputs used were the number of employees, capital costs (CAPEX) and other operational costs and as outputs we considered separately the amounts of treated and recycled urban waste.

As mentioned, all models adopted an input orientation since they follow demand side management policies. All the data were obtained from the annual activity and account reports published by the operators and from the annual reports of the Portuguese regulator (ERSAR).

4.2 Results

For the 'retail' market, the results indicate that there are diseconomies of scope, since the frontiers of separate production mostly dominate the frontiers of joint production, considering diverse α values. This is also proved by the circumstance of, on average, $\theta_j < \theta$ and thus the average of $\hat{\theta}$ is always less than one (see Table 6). In this case, the ratios $\hat{\theta}$ are relatively low, which clearly shows that there are strong diseconomies of scope.

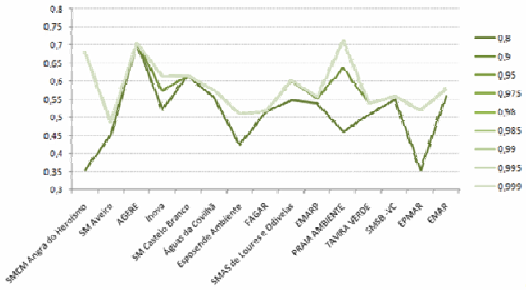
Table 6 – (Super-)Efficiencies and ratios $\hat{\theta}$ in the 'retail' market

			θ	θ_j	$\theta^{\wedge} = \theta_j/\theta$	**Economies of scope**		**Diseconomies of scope**	
θ_j (α=0.999)	θ (α=0.995, 0.999)	Average	0.879	0.503	0.569	---	**0**	0.569	**15**
		Median	0.960	0.505	0.561	---		0.561	
		St. Dev.	0.151	0.122	0.069	---	**0%**	0.069	**100%**
		Max.	1.000	0.692	0.692	---		0.692	
		Min.	0.581	0.325	0.480	---		0.480	

Despite the asymmetry observed in the operators of the sample the robustness of the results is conferred by the methodology adopted itself, that is, the robust non-parametric approach of order-m, which has the capacity to "re-sample" the sample.

In addition, we may observe through Figure 4 that as the values of increase, tending to 1 (that is, as we move towards the full frontier of joint production FDH), the ratios $\hat{\theta}$ also increase, but always lower than the unity. This sensitivity analysis proves the consistency (and presence) of diseconomies of scope.

Order-α frontier (α=0.995) of separate production (Ws+Uw) and relative to various order-α frontiers (α=0.8 to 0.999) of joint production (WsUw)



Order-α frontier (α=0.999) of separate production (Ws+Uw) and relative to various order-α frontiers (α=0.9 to 0.999) of joint production (WsUw)

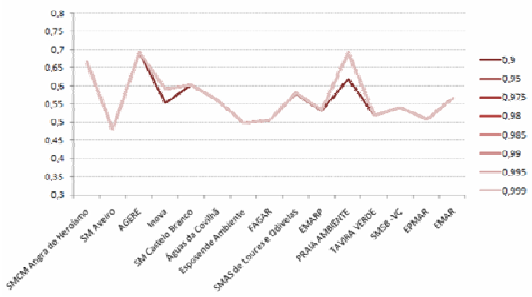


Figure 4 – Ratios $\hat{\theta}$ of multiproduct operators

By comparing Figure 4, we can also observe that as we approach to the FDH full frontier of the separate production, the ratios $\hat{\theta}$ will also increase.

On the issue of scale economies, it is observed that the largest percentage of operators in the 'retail' market has a technology of increasing returns to scale (IRS). However, there is also a considerable percentage of operators with a technology of decreasing returns to scale (DRS), especially when Model I is took into account. Figure 5 shows the results.

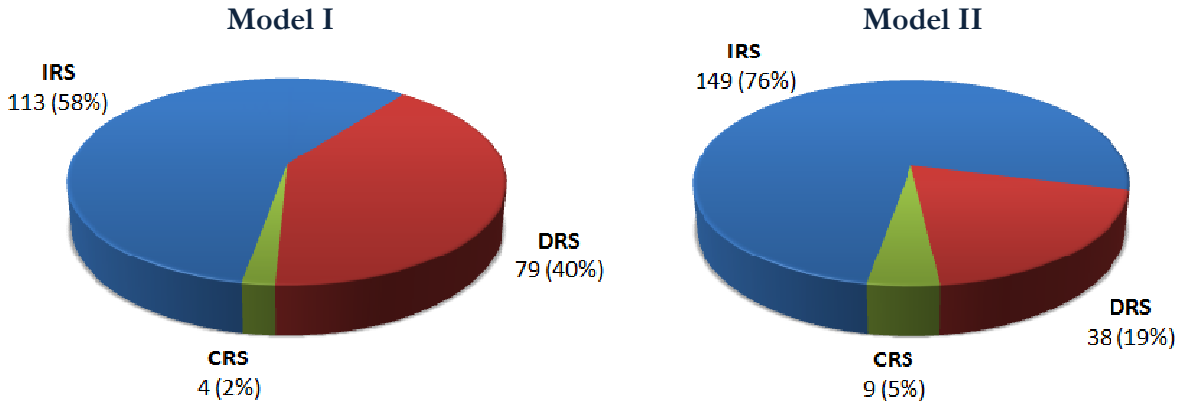


Figure 5 – Returns to scale on 'retail' market

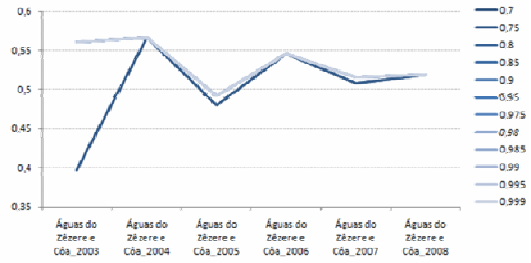
Thus, the results seem to indicate that the urban waste sector in the 'retail' market in Portugal should evolve towards specialization and increase the size of most operators to move closer to the optimal market structure.

Regarding the search for scale and scope economies in the "wholesale" market, we carried out a set of analysis, given the greater variety of operators in the sector. These analyses consisted of comparing the separate production frontiers WsWw+Uw, WsUw+Ww, Ws+Ww+Uw and Ws+Uw with the frontiers of joint production WsWwUw and WsUw, where here Ws means the water only companies and Ww the wastewater only companies. The results show that there are strong diseconomies of scope in the 'wholesale' market, since $\hat{\theta}$ takes, on average, relatively low values (see Table 7 and Figure 6). The corresponding analysis of the study of separate production frontiers WsUw+Ww leads, however, to the conclusion that there are scope economies in the 'wholesale' market. Nevertheless, we believe that this analysis should not be taken into account, since the frontier of separate production was obtained from a not significant small set of operators WsUw not significant, that is, from only one operator that provides the water supply and the urban waste service.

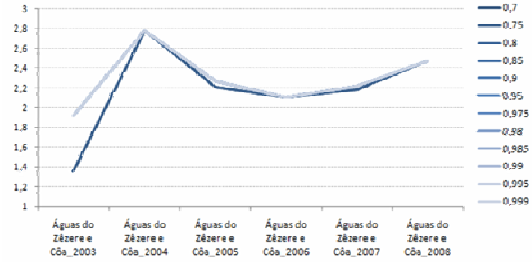
Table 7 – (Super-)Efficiencies and ratios $\hat{\theta}$ in the 'wholesale' market

			θ	θ_j	$\hat{\theta}=\theta_j/\theta$	Economies of scope		Diseconomies of scope	
WsWw+Uw	θ (α=0.995, 0.999)	Average	0.991	0.529	0.533	---	**0**	0.533	**1**
		Median	1.000	0.532	0.532	---		0.532	
		St. Dev.	0.016	0.036	0.029	---		0.029	
		Max.	1.000	0.566	0.566	---	**0%**	0.566	**100%**
		Min.	0.962	0.473	0.492	---		0.492	
WsUw+Ww	θ (α=0.995, 0.999)	Average	0.991	2.271	2.291	2.291	**1**	---	**0**
		Median	1.000	2.178	2.239	2.239		---	
		St. Dev.	0.016	0.305	0.299	0.299		---	
		Max.	1.000	2.776	2.776	2.776	**100%**	---	**0%**
		Min.	0.962	1.916	1.916	1.916		---	
Ws+Ww+Uw	θ (α=0.995, 0.999)	Average	0.991	0.436	0.439	---	**0**	0.439	**1**
		Median	1.000	0.430	0.433	---		0.433	
		St. Dev.	0.016	0.041	0.037	---		0.037	
		Max.	1.000	0.491	0.491	---	**0%**	0.491	**100%**
		Min.	0.962	0.384	0.400	---		0.400	
Ws+Uw	θ (α=0.995, 0.999)	Average	0.967	0.360	0.371	---	**0**	0.371	**1**
		Median	1.000	0.352	0.356	---		0.356	
		St. Dev.	0.071	0.098	0.089	---		0.089	
		Max.	1.000	0.561	0.561	---	**0%**	0.561	**100%**
		Min.	0.810	0.253	0.302	---		0.302	

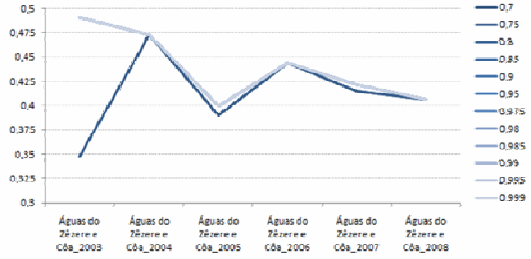
Order-α frontier (α=0.999) of separate production (WsWw+Uw) and relative to various order-α frontiers (α=0.7 to 0.999) of joint production (WsWwUw)



Order-α frontier (α=0.999) of separate production (WsUw+Ww) and relative to various order-α frontiers (α=0.7 to 0.999) of joint production (WsWwUw)



Order-α frontier (α=0.999) of separate production (Ws+Ww+Uw) and relative to various order-α frontiers (α=0.7 to 0.999) of joint production (WsWwUw)



Order-α frontier (α=0.999) of separate production (Ws+Uw) and relative to various order-α frontiers (α=0.7 to 0.999) of joint production (WsUw)

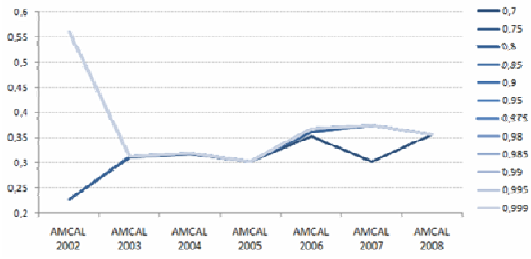


Figure 6 – Ratios $\hat{\theta}$ of multiproduct operators of the 'wholesale' market

Regarding economies of scale in the "wholesale", as in the 'retail' market, we can also observe that there are many operators with a technology of increasing returns to scale (IRS), although to a lesser extent than in the retail sector. There are also a significant number of operators with decreasing returns to scale (DRS) as shown in Figure 7. Thus, in general, we may assume that there are also economies of scale in the 'wholesale' market.

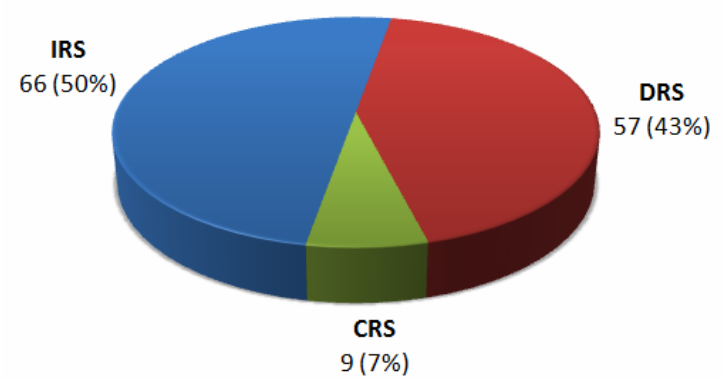


Figure 7 – Returns to scale on 'wholesale' market

5. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we intended to evaluate the existence of economies of scope by means of a recent and robust methodology, based on partial frontier nonparametric methods which are more robust and have more interesting properties than the traditional full frontier nonparametric methods (of DEA and FDH). In addition we also evaluate the economies of scale using the DEA method.

We truly believe that this study makes relevant contributions to the waste sector literature. In particular, the analysis of scope economies in the waste sector represents the most important one, due to the absence of studies on this matter. Moreover, the computation and application of the recent approach based on the order-α also represents a relevant step for this kind of analysis, besides the fact of having several advantages over the parametric approaches which are widely used in other sectors.

The results obtained in this research show that there are strong diseconomies of scope either in the „wholesale" or „retail" markets in the waste sector in Portugal. What this means for public managers and politicians is that the combined provision of these services (waste, water and wastewater) cannot offer true cost savings to the community at large. Although some economies can be achieved between water and wastewater services (Carvalho and Marques, 2010), the same does not seem to be true for the waste services.

Economies of scale were found in „wholesale“ and „retail“ market, but to a lesser extent in the „wholesale“ market. This means that, in general, operators must invest in specialization on the urban waste services and assume a larger size (that is scale), particularly in the „retail“ market, to improve the performance of the services provided.

Finally, these outcomes should be seen as an incentive to reform the waste sector, in particular, the retail market, which reveals itself more prone to cost savings. Although more empirical work will be needed, in fact this paper proves that market structure in waste sector does matter.

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