O Modelo de Governação e o Desempenho Económico e Ambiental de Entidades Gestoras de Águas e Resíduos: Análise Exploratória

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RESUMO

É comummente argumentado que os modelos de governação influenciam os desempenhos económicos e ambientais dos serviços públicos. Também é comum o argumento de que as entidades gestoras de maior dimensão são mais eficientes do que as menores. Com base nestas regularidades comummente discutidas, são apresentados argumentos a favor da fusão e da gestão privada de serviços públicos nos sectores dos resíduos e da água. O presente artigo pretende explorar estes argumentos em Portugal, introduzindo outras considerações, tais como as características das empresas e dos municípios servidos. Os dados utilizados foram extraídos de RASARP2022. O desempenho económico foi avaliado utilizando o rácio de cobertura de gastos, o desempenho ambiental foi aproximado pelo volume de perdas reais de água no caso do abastecimento de água, colapsos de condutas, no caso das águas residuais, e quantidade de recolha seletiva de resíduos urbanos, no caso das estações de tratamento de resíduos. Os resultados preliminares parecem indicar que o modelo de gestão não é o único determinante, mas outras variáveis são também relevantes para determinar o desempenho económico e o desempenho ambiental de entidades gestoras.

Palavras-Chave: Modelo de governação, sustentabilidade, análise multivariada, serviços de água, serviços de resíduos

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Governance Model and Economic and Environmental Performance of Water and Waste Utilities: An Exploratory Analysis

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ABSTRACT

It is widely argued that governance models influence utilities' economic and environmental performance. A common assumption is that bigger utilities are more efficient than smaller ones. Based on these commonly discussed regularities, arguments are made for the merger and the private management of utilities in the waste and water sectors. This paper aims to explore these arguments in Portugal by introducing other considerations, such as the characteristics of the entities and of the municipalities served. The data used was extracted from RASARP2022. Economic performance was assessed using the cost-recovery ratio, and environmental performance was proxied by the volume of real water loss in the case of Water provision, System collapses in the case of wastewater, and the quantity of separate collection of urban waste in the case of waste treatment plants. The preliminary results show that the management model is not the only determinant; other variables are also relevant to determining economic and environmental performance.

Keywords: Governance model, sustainability, multivariate analysis, water utilities, urban waste

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1 Introduction

Public water supply, urban wastewater sanitation and urban waste management are structural public services essential to the population's well-being, safety, and public health. Therefore, they must comply with guiding principles, including universal access, continuity, efficiency, quality of service, and fair prices. In line with these principles, the European Union defends that water and waste management must consider economic, ecological, and social dimensions to ensure the sustainable and efficient use of water resources. Considering growing environmental challenges, which we are all witnessing, including population growth, urbanization, and climate change, the water and waste sectors face increasing pressure (Romano, Guerrini & Marques, 2017).

In Portugal, these services are legally recognized as essential public services under the national legislation, specifically by the Essential Public Services Law (Lei nº 23/96, de 26 de julho) (RASARP, 2022). Most of the public service infrastructure in this sector constitutes a natural monopoly. It imposes significant costs (investments and environmental impacts) on society and generates positive externalities (e.g., time savings and access to water and energy). Despite being delivered through market-based mechanisms in some cases, these services remain an ultimately governmental responsibility due to their special role (Marrewijk et al., 2008).

Due to a large number of management entities, the complexity of this sector makes it problematic to define and apply a single and universal governance model capable of responding effectively to its multidisciplinary and intersectoral nature. These services typically operate as natural monopolies, where technological constraints mean that a single provider serves each geographical area, with limited user choice (Ferreira da Cruz & Marques, 2011). Therefore, the comparison of efficiency between governance alternatives for water service delivery cannot be undertaken without understanding how local officials opt between in-house alternatives and externalization solutions. In other words, the profit motive is a strong incentive for the externalization of water and urban waste service delivery.

The primary aim of this study is to explore the relationship between governance models and the performance of utilities by reviewing relevant literature and using economic and environmental indicators available in the RASARP 2022 database. Additionally, it analyzes the relationship between the size of the company and its performance. For this purpose, two research questions guide the study:

Q1: Do utilities' environmental and economic performance differ depending on the governance model?

Q2: Does it remain statistically significant when territorial characteristics are included?

As an exploratory study, the findings aim to provide preliminary insights and are indications for the development of future research.

2 Materials and Methods

2.1 Description of the water sector

The value chain of water and waste management services allows us to understand their complementarity as fundamental components of what is traditionally known as basic sanitation. These services have been categorized as wholesale ("Alta") and retail ("Baixa") operations, depending on the activities carried out by the various management entities.

In Portugal, all water services, including drinking water supply, wastewater collection and treatment, fall under the responsibility of local governments. A notable distinction from other countries is that, in Portugal, both water and wastewater sectors are not, as a rule, vertically integrated (Ferreira da Cruz et al., 2012). Multi-municipal systems primarily carry out wholesale management, while retail management is the responsibility of individual municipalities. These two levels correspond to upstream (wholesale) and downstream (retail) stages of service delivery in water supply, wastewater sanitation, and urban waste management.

From a market structure perspective, the water sector is a typical example of a network industry in wholesale and retail operations. These services are characterized as natural monopolies, meaning they are not competitive by nature due to high infrastructure costs and network constraints. Regulation of the sector, particularly economic regulation, is essential to reduce social welfare losses and inefficiencies resulting from a monopoly. Regarding resource use, the water sector is capital-intensive, with long payback periods. This characterization is justified by the high investment required in the initial phase, whose return only occurs in the long term, with the smoothing of tariffs over the infrastructure's useful life. (RASARP, 2022).

This sectoral structure has led to economies of scale and justified the value chain division for the provision of services, considering the stages of the production process. However, the Portuguese water sector is characterized by a high degree of fragmentation, with water distribution managed by 260 local water utilities, responsible for the distribution and customer service, with substantial overlap with the territorial limits of the 278 mainland municipalities.

For the retail water supply service, there are 232 low-level management entities. Among them, 173 operate under a direct management model called "Internal Service", followed by delegated management models and concessions. At the wholesale level, there are 18 wholesale entities. However, only 10 are considered in performance indicators, according to ERSAR (Portuguese Regulatory Authority of Water and Waste Services), as inter-municipal water transfers (e.g., one municipality selling water to another) are excluded. Therefore, these 10 entities, primarily responsible for collecting, treating and selling water to retail distributors, mostly adopt the concession as their management model.

In wastewater service, there are 225 retail management entities. The majority, 172 entities, adopt a direct management model (Internal Service), 30 operate under delegation, and only 23 adopt municipal concessions. Regarding wholesale wastewater management, which is handled by 12 entities, the most common model is the concession, and 8 of these entities are managed through multimunicipality concessions. Table 1 summarizes the number of entities and the institutional arrangements adopted in the water sector.

Table 1. Management models in the Water Sector

Management Model		Water supply			Wastewater		
		Wholesale	Retail	Total	Wholesale	Retail	Total
Concessionary Management	Multimunicipal concessions	6	1	**6**	8	0	**8**
	Municipal concessions	4	26	**27**	2	23	**25**
Delegated Management	State delegations	1	1	**1**	0	0	**0**
	State/Municipality Partnerships	1	3	**4**	1	3	**4**
	Municipal and intermunicipal companies	1	28	**29**	0	27	**27**
Internal service	Association of municipalities	0	0	**0**	1	0	**1**
	Municipalized or intermunicipal services	3	18	**18**	0	17	**17**
	Municipal services	2	155	**155**	0	155	**155**
	Total	**18**	**232**	**240**	**12**	**225**	**237**

2.2 Description of the urban waste sector

In Portugal, urban waste management services operate under a legal monopoly framework, established as a national strategic choice, to ensure a single provider for each geographical area. Like the water sector, this service also requires a substantial initial investment. It involves a complex logistical and technological system that includes the collection, transport, sorting, recovery, and disposal stages of household waste. These services may also include other types of waste similar in nature or composition to domestic waste (RASARP, 2022).

The national framework establishes that collecting municipal waste is the responsibility of 237 retail-level management entities, operating across Portugal’s 278 mainland municipalities. Only 24 are directly responsible for multi-material selective collection (APA, 2020). In this way, local governments coordinate with 23 upstream management entities, known as SGRU (Urban Waste Management Systems), responsible for the service's subsequent stages, such as transport, treatment and recovery or disposal. In this context, it must be emphasized that in Portugal, the SGRU plays a central role in the success and effectiveness of the system, as municipalities alone often lack the capacity to meet citizens’ demands fully. Given the intrinsic nature of urban waste collection and treatment, which depends heavily on developing technological models for resource optimization, integrated cooperation between local governments and specialized entities is essential.

Regarding institutional arrangements, the decentralization of public services has increased the responsibilities of municipalities in various domains. As a result of the transfer of power from the central government to local authorities, these organizations were forced to establish a network and partnerships with various private actors and non-profit organizations to deliver urban waste services more effectively (Ferreira da Cruz & Marques, 2011).

In Portugal, most municipalities collaborate to achieve economies of scale and improve operational efficiency in this sector. Analyzing the characteristics of municipalities, it is easy to understand the need for cooperation, firstly from shared geographic conditions, interdependence, or common challenges, which encourage the shared use of infrastructure and resources across different stages of the waste management process. In addition, since legislative reforms in 2013, private operators have also been allowed to hold controlling interests in concessionaire entities managing multi-municipal systems

(RASARP, 2022), which has provided local governments with a new alternative for providing this service.

Currently, five main institutional arrangements are used by municipalities to provide urban waste management services: (1) Municipal services, managed and provided directly by the local government (internal service); (2) Municipalized services, are also part of the internal services of a local authority, but operated in an industrial framework; (3) Municipal companies, part of the Local Business Sector, appear as an alternative to both internal services (described above) and market outsourcing (Ferreira da Cruz & Marques, 2011); (4) Intermunicipal companies, mechanisms of cooperative arrangements, in which multiple municipalities join forces and manage services to pursue shared objectives; (5) Private concessions (Delegation), an alternative to internal provision. Local authorities use market mechanisms by contracting out to private operators (through outsourcing or franchising) for some services.

Table 2 summarizes the distribution of entities and the institutional models adopted in the urban waste sector.

Table 2. Management models in the Urban Waste Sector

Management Model		Urban Waste		
		Wholesale	Retail	Total
Concessionary Management	Multimunicipality concessions	12	0	12
	Municipal Concessions	0	0	0
Delegated Management	State delegations	0	0	0
	State/Municipality Partnerships	0	0	0
	Municipal and intermunicipal companies	9	20	27
Internal service	Association of municipalities	2	2	4
	Municipalized or intermunicipal services	0	8	8
	Municipal services	0	207	207
	Total	**23**	**237**	**258**

3 Data and Methodology

The data used in this study were extracted from the 2022 edition of the RASARP report, published by ERSAR, and correspond to indicators from 2021. It is important to note that, according to ERSAR in this report, the indicators used to evaluate the quality of water and wastewater services provided to users correspond to the third generation of the assessment system (RASARP 2022, pages 185-186). This information was supplemented with statistical information from INE (Statistics Portugal) to characterize municipalities.

In the water sector, we evaluated environmental performance using the following variables: Real water losses (AA12b), Non-billed water (AA08b), and Energy efficiency of pumping stations (AA13b). The Cost recovery ratio (AA06b) proxied the economic aspect.

For the wastewater sector, the environmental performance was assessed by the Occurrence of floods (AR03b), and the economic dimension was proxied by the Cost recovery ratio (AR05b).

For the waste sector, the environmental performance was proxied by volume of recycling activity (PRU38b), while the economic dimension was assessed by the cost recovery ratio (RU06ab). For clarity, Annexe 1 includes the complete list of variables used in the analysis.

The dimension and utility size were assessed by either the population served or the amount of waste collected. Considering the area's characteristics, we integrated an ordinal scale of degree of urbanisation, the area (km2), and the difference between the maximum and minimum altitude in the case of the water sector. The social variables included are population density and an income measure (Income index).

Finally, the methodological approach consisted of two main phases. First, the data were analyzed using descriptive statistics and nonparametric tests to compare means and medians across different management models. Subsequently, in the second phase, two econometric techniques were applied: (i) multiple linear regression, to assess the influence of management models and contextual variables on performance outcomes; and (ii) qualitative data econometric models (multinomial logit model), to estimate the probability of a particular management model being adopted, based on both performance indicators and territorial or socioeconomic characteristics. We assume no specific direction of causality in the analyses, and all results should be interpreted as preliminary.

4 Results and Discussion

This section presents the main empirical findings, structured by sector: water supply, wastewater, and urban waste. We compare economic and environmental performance across different management models for each sector and control for physical, social, and institutional variables. Our results are based on descriptive statistics, nonparametric tests, and regression analysis.

Preliminary evidence suggests that in the water sector (retail), which includes 229 entities, 66% operate under direct management, followed by the delegation to a municipal or inter-municipal firm, or under concession. In the case of wastewater, 225 entities are considered, most of which (155) are directly managed, followed by 27 under delegation to municipal or inter-municipal, and 23 in concession. Finally, the waste sector considered in this study comprises 237 entities (retail), most of which operate under direct management (87%), followed by the delegation to municipal or inter-municipal entities.

That said, management models are not the only determinant of utility performance. Contextual variables, such as the degree of urbanization, geographic characteristics, and income levels, also play an important role.

4.1 Main results for the water supply sector

Analyzing the difference in environmental performance across different water utility management models, our results reveal statistically significant differences in both mean and median values of Real water losses (AA12b). Similar results were found for non-billed water (AA08b) and the economic indicator cost recovery ratio (AA06b), which vary significantly according to the management model. Regarding the Energy efficiency of pumping stations (AA13b), statistically significant differences were also observed across different governance models.

When comparing management models by territorial variables, their distribution varies significantly across degrees of urbanization. In particular, physical/geographic variables such as area and altitude range (altimetry) influence the average real water loss.

Focusing on the behaviour of the Cost recovery ratio (AA06b) variable, the main conclusion is that the management model significantly affects performance when physical and social characteristics are controlled. However, this effect is statistically significant only for the direct management model.

In the case of Unbilled water (AA08b), only a few contextual variables show statistical significance: area (5.3%), altimetry (1.4%), and municipality typology, specifically predominantly rural areas (5%). For this variable (AA08b), the management model does not influence performance significantly.

These findings are based on statistical analyses to compare mean and median values across management models, as summarized in Table 3.

Table 3. Mean and Median indicator values for water supply sector; *p≤10%; **p≤5; ***p≤1%

Indicator	Mean	Median
AA12b	*	**
AA06b	***	***
AA08b	****	***
AA13b	***	***
PAA11b	***	***
PAA14b	*	***
Area (km^2)		*
Altimetry (altitude)	*	
Population Density	***	***
Income index	***	***

For the analysis, we also explored and examined the likelihood of any utility adopting a particular management model, controlling for environmental and economic performance indicators and physical and social characteristics.

The results indicate that the probability of observing any given model is significantly determined by the variable AA06b (Cost recovery ratio). The Income Index is statistically significant across all models, with the most substantial effect observed in the Delegation (state-owned company) model. Additionally, the variable PAA14b (Type of intervention area) and the altimetry variable also show relevance in explaining model choice.

When considering Non-billed water (AA08b) variable, statistically significant influences are found only for the following models: Concession (municipal concession), Delegation (municipal company), and Direct management (municipalized service). For the Delegation (state-owned company) model, the variables Income Index and PAA14b, specifically, the classification as a predominantly urban area, are statistically significant at 0%. In the Delegation (municipal company) model, the PAA14b variable, predominantly urban area, also shows significance.

Then, the variable Real water losses (AA12b) significantly affects the likelihood of several management models being adopted, most notably: Direct management (municipalized service), Concession (municipal concession), Delegation (municipal company), and, less relevant for the Delegation in state companies.

For this variable (AA12b), the Income Index shows statistically significant results of <5% in these models: Direct management (municipal service), Concession (municipal concession), and Delegation (municipal company). However, it also shows 0% in the Delegation (state-owned company) model. In addition, the variable PAA14b (Type of intervention area) also shows broad statistical significance across models. Altimetry is again particularly relevant in the Delegation (state-owned company) model.

Regarding the variable Energy efficiency of pumping stations (AA13b), significance is only relevant for Delegation (state company), and marginally for Delegation (municipal company). For this variable (AA13b), the Income Index is statistically significant for the following models: Direct management (municipalized service) (1%); Concession (municipal concession) (6.5%); Delegation (state-owned company) (0%). In addition, the variables PAA14b (Type of intervention area), area and altimetry all demonstrate statistical significance in explaining differences in performance related to this indicator.

Table 4 presents the results of the regression models and indicates the influence of the management model and contextual variables on performance in the water supply sector.

Table 4. Regression model water supply sector; *p≤10%; **p≤5; ***p≤1%

Indicator (dependent variable)	Management Model only	Management Model with controls
AA12b	*	Global significant (***) MM (*) Area (*) Altimetry (**)
AA13b	**	Global Significant (**)
AA06b	***	Global Significant (***) MM (*) Urbanization (***)
AA08b	***	Global Significant (***) MM (***) Urbanization (***) Area (***) Altimetry (***)

4.2 Main results for the Wastewater sector

A statistical analysis was initially conducted to analyse the wastewater sector to compare the mean and median values of performance indicators across different management models, as presented in Table 5.

Table 4. Mean and Median indicator values for wastewater sector; *p≤10%; **p≤5; ***p≤1%

Indicator	Mean	Median
AR05b	***	***
AR03b		*
AR10b	*	*
PAA14b		
PiAR06b		
Area (km^2)		
Population Density	***	***
Income index	***	***

For the variable AR03b (Occurrence of floods), management models do not appear to explain differences in performance significantly. However, the variable PAA14b (Type of intervention area) shows statistical relevance for this indicator, with predominantly rural areas (1.5%) and predominantly urban areas (1%) both demonstrating significance. Additionally, the median value of flood occurrence is significant at 10%.

The linear regression results for AR05b (Cost recovery ratio) show statistical significance when compared across management models. Moreover, the variable PAA14b (Type of intervention area) also shows relevance here, with significance at the 10% level. In contrast, AR10b (Pumping station energy efficiency) is not statistically significant in this model.

Examining the prevalence of each management model, using a multinomial logit model, several variables were found to be significant. For the Delegation (municipal company) model, the relevant predictors include Physical accessibility (PiAR01b), Occurrence of floods (AR03b), and Population density. Additionally, using treated wastewater (PiAR03b) is significant at the 1% level. In the case of Direct management (municipalized service), the following variables show statistical significance: PiAR01b (Physical accessibility) and PiAR06b (Density of branches) at 5%; AR03b (Occurrence of floods) and Predominantly urban areas at 10%; and Predominantly rural areas at 1%.

These findings highlight the role of physical infrastructure and territorial classification in influencing the management model. Table 6 presents the regression models' results that demonstrate these variables' significance in explaining model performance in the wastewater sector.

Table 5. Regression model wastewater sector; *p≤10%; **p≤5; ***p≤1%

Indicator (dependent variable)	Management Model only	Management Model with controls
AR05b	***	Global significant (***) Income index (***)
AR03b		Global Significant (***) Urbanization (***) MM (**)
AR10b		Global Significant (***) MM (**) Urbanization (***)

4.3 Main results for the Municipal Urban Waste sector

For the municipal waste sector, the results show that for the variables RU06ab (Cost recovery ratio), PRU38b (Volume of recycling activity), and PRU89b (Selectively collected urban waste), the median values differ significantly across management models, although the mean values do not. Additionally, some of these indicators show statistically significant differences when comparing different degrees of urbanization.

Table 6. Mean and Median indicator values for urban waste sector; *p≤10%; **p≤5; ***p≤1%

Indicator	Mean	Median
RU06ab	***	***
PRU89b	***	
PRU38b	**	
PRU3ab	***	***
Area (km^2)		**
Population Density		**
Income index	***	***

Similar to the analyses conducted in other sectors, the results here indicate that the management model is not consistently statistically significant when controlling for other variables. In contrast, the degree of urbanization variable (PRU3ab) tends to show statistical significance, and in some models, physical variables are also relevant. Regarding the probability of adopting a particular management model, models could not be estimated in this study due to data limitations and a reduced number of valid observations.

Table 8 presents the regression analysis results, indicating where the management model significantly explains performance in the municipal urban waste sector.

Table 7. Regression model urban waste sector; *p≤10%; **p≤5; ***p≤1%

Indicator (dependent variable)	Management Model only	Management Model with controls

RU06b	***	Global Significant (***) MM (**) Urbanization (***)
PRU38b	***	Global Significant (***) MM (not significant) Urbanization PRU33b Area

5 Conclusions

The topic of the efficiency of water and waste sector utilities has been reviewed previously in the literature (Ferreira da Cruz et al, 2012; Lannier & Porcher, 2014; Romano, 2017); however, the interaction between the role of the governance model, combined with the influence of physical and social characteristics, remains underexplored in the Portuguese case. This study examined the relationship between governance models and utilities' economic and environmental performance in these Portuguese sectors.

Our results suggest that although performance varies across management models, these models are not the only determinants of efficiency. In the water and wastewater sectors, performance is also significantly influenced by other factors, such as utility size, geographic features (e.g., altimetry and area), population density, and income levels. The effect of governance models appears more prominent in the wastewater sector than in the waste sector, where results are more ambiguous.

Furthermore, the cost recovery ratio and environmental indicators, such as water losses or flood occurrence, vary across management models. In this sense, including contextual variables often reduces the statistical significance of the management model itself. This suggests the need for a more integrated analytical approach that accounts for territorial and institutional diversity when evaluating utility performance.

In conclusion, governance models do matter, but not in isolation. Future research should adopt more refined models to understand the effects of ownership, operational scale, and local context, and to assess performance over time. Future research would provide more substantial evidence for policymakers considering reforms in public service delivery.

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Annex 1 **Coodebook of variables analyzed**

Indicator	**Description**
Water Sector (AA)	
AA06b	Cost recovery ratio
AA08b	Non-billed water
AA12b	Real water losses
AA13b	Energy efficiency of pumping stations
PAA11b	Number of accommodations served
PAA14b	Type of intervention area
Area (km^2)	Area of each municipality
Altimetry (altitude)	Altitude range of each municipality
Population Density	Number of inhabitants per square kilometer in each municipality
Income index	Corresponds to an equation involving a set of variables
WasteWater Sector (AR)	
AR03b	Occurrence of floods
AR05b	Cost recovery ratio
AR10b	Energy efficiency of pumping stations
PAA14b	Type of intervention area
PiAR01b	Physical accessibility
PiAR03b	Use of treated wastewater
PiAR06b	Density of branches
Area (km^2)	Area of each municipality
Population Density	Number of inhabitants per square kilometer in each municipality
Income index	Corresponds to an equation involving a set of variables
Urban Waste Sector (RU)	
RU06ab	Cost recovery ratio
PRU38b	volume of activity for recycling
PRU89b	Selectively collected urban waste
PRU3ab	Type of intervention area
PiAR01b	Physical accessibility
Area (km^2)	Area of each municipality
Population Density	Number of inhabitants per square kilometer in each municipality
Income index	Corresponds to an equation involving a set of variables