A Work Project, presented as part of the requirements for the Award of a Masters Degree in Management from the NOVA – School of Business and Economics.

Redefining the Organization of the Public Water Supply Sector:

An Analysis of Costs and Performances in the Portuguese Market

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A Project carried out on the ERSAR's Business Project, under the supervision of the professor Constança Casquinho

20-May-2016

Abstract

The role of regulators in the public sector has never been so challenging. Their function of identifying and amending costs misallocations within operators' financial statements is constantly threatened by operational inefficiencies and abuses of the local government funds. While encouraging investments, regulators have to deal with the local economic and political situation. Portugal is suffering from a critical fiscal recession that is alarmingly constraining the government budget. On top of this, the municipalities are lowering tariffs to gain citizens' consensus, creating unsustainable public debts. This paper aims at facilitating the detection of these flaws through the implementation of a financial model, to in turn enhance operators' sustainability while protecting citizens' interests.

Keywords: • ERSAR, • Public Water Sector, • Cost Analysis, • Quantitative Management

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1. Brief Context

The first section of this paper aims at giving a broad synopsis of the work done in the CEMS Business Project. It begins with a description of ERSAR, the client with whom the team has worked during the last semester of master studies, and an overview of the Portuguese Public Water Industry, to have an overview of the sector dynamics and recent developments. Subsequently, the current situation of the client is analyzed, alongside with the specific challenge that they proposed the team to undertake.

a. ERSAR

The *Entidade Reguladora dos Servios de Aguas e Residuos* (ERSAR) is the authority responsible for the Portuguese Water and Waste Services Regulation. It developed from the former *Instituto Regulador de Agua e Residuos* (IRAR) in 2009 and it is headquartered in Lisbon. ERSAR regulates three pubic services, namely the Water Supply, the Wastewater Management and the Municipal Waste (see **Appendix 1**). The main scope of this organization is to protect Portuguese consumers through an equal and transparent access to all the above mentioned services provided by the local Management Entity (EG). Moreover, it assures that the operators provide them their truthful financial statement.

Among the three areas of activity only the first two fall within the scope of this paper. Therefore, the Municipal Waste area will not be considered further. The services within the Water Supply can be divided into two classes: bulk and retail. The former is responsible for the water collection, treatment, and transportation to a general hydraulic system. The latter is instead in charge of the distribution of water to the end-consumers and the drainage of wastewater, which is subsequently treated and delivered to its final destination by the bulk operator. The Wastewater Management process is indeed similar but specular to the Water Supply one (ERSAR, 2015).

b. Market Overview

The water and waste sector in Portugal is a stabilized market characterized by a complex structure and a convoluted offer of services. The sector includes 381 drinking Water Suppliers of which 366 are retail operators and 15 bulk operators. Moreover, it includes 283 Wastewater Management entities of which 264 are retail operators and 19 bulk operators. Overall the Portuguese population served is of about 10 million people (ERSAR, 2015). The Portuguese market is characterized by a monopolistic competition, meaning that each municipality can have only one operator responsible for the services. It generally implies a lower incentive for operators to increase efficiency, a risk of lower quality of service and a risk of dominance of the operator over consumer interests (Rosa, 2011).

In Portugal, the ownership of the three public services belongs to either the State or the Municipalities. While the State is in charge of the multi-municipal systems, the Municipalities are only in charge of the municipal system. In turn, the single operators are liable for the management and operations of the municipal system. Regarding the management model, they can choose among three different ones: Direct Management, Delegation or Concession. Besides, the operators can promote either Public-Private-Partnerships or Public-Public-Partnerships, in order to foster innovation and reach bigger scales.

Regarding the tariffs, these are finally set by the regional operators but initially proposed by the regulator. The tariffs vary between 0.31 to 0.55 euro per cubic meter, while sewer tariffs vary between 0.33 and 0.54 euro per cubic meter (ERSAR, 2016). Although in Water Supply systems the cost recovery levels are satisfactory, the situation regarding sanitation is clearly unsustainable. The coastal urban regions show greater cost recovery ratios than the inland regions, especially regarding the northeast district where the costs are higher and revenues are lower (Monteiro, 2007).

c. ERSAR Current Situation

ERSAR's role as a supervisor and regulator that protects the stability of the industry is assisted by the Portuguese Government in the formulation, implementation and monitoring of the strategies that the multitude of municipalities adopt with regards to the water and waste sectors. It is possible for ERSAR to indirectly govern EGs' behavior by renewing the local legislation that all these entities are forced to abide. Moreover, it serves as an economic regulator to ensure a socially acceptable pricing system that both reflects the true costs of the municipalities and that permits them to become financially sustainable.

Regarding the end-user tariffs, their expenses with water and waste services are defined for each municipality, according to three different levels of use: 60, 120 and 180 cubic meters. The procedure of defining the tariffs depends on the operator's management model. It can be split into two groups:

- Concessionaires of municipal utilities: they are regulated according to a concession contract and have to comply with the tariffs update. Moreover, they also have to review formulas set on their contracts. In this case, ERSAR is entitled to opinion on the concession contract template and to supervises what was previously agreed upon.
- All other municipal owned systems: they follow a different management model. These systems are subject to a different tariff selection criterion, as well as to a distinguished process of tariff approval.

The absence of tariffs or disparities in the criteria used to set those, points to the need of characterizing and blending them in order to permit full recovery of costs while providing the different services (ERSAR, 2016). To ensure that, ERSAR collect data from all the Portuguese municipalities and, integrating them with the regional database (see **Appendix 2**), it analyzes the EGs according to its 16 internal indicators. After analyzing all this data, ERSAR should validate that the costs reported by the operators are truthful and then set the tariffs accordingly.

d. The Business Project Challenge

Throughout the last few years, ERSAR has been gathering tremendous quantity of interesting data from all the Portuguese EGs. However, due to time constraints and data reliability issues, they could not make use of this numbers to formulate tailored strategic analysis. Moreover, some data turned out to be biased, corrupted. The issue consists in the municipalities having incentives to underestimate their costs to seem more efficient and to be able to set lower tariffs. Giving that these EGs are subsidized by the local municipality, in the long run the situation has become no longer financially sustainable.

The CEMS Team, together with ERARS' specialists, has been working out a system to analyze all the available data and to unveil voluntary and/or non-voluntary costs misallocations in each EG. The final scope is to help ERSAR setting an optimal tariff that will enable EGs' long-term financial sustainability while protecting the interests of the end-consumers. Therefore, a financial model has been created to group the municipalities according to operations, activity and scale. Then, according to reliability and efficiency, the model chooses the best EG within each group, to finally compare it with all the entities within the same cluster to cross-check whether the financial statements can be considered truthful or not.

2. Reflection on the Work Done and Individual Contribution

a. Problem Definition

To begin with, it is worth mentioning the difficult economic situation that Portugal has been facing in the last ten years. In 2014, the country recorded a 7.2% deficit. The government budget averaged -5.27% of GDP from 1995 until 2015, reaching an all-time high of -3% of GDP in 1999 and a record low of -11.20% of GDP in 2010. Since 2009, Portugal has been slowly recovering, and in 2015 the public budget deficit came in at 4.4% of the GDP. Figures turned out to be worse than an earlier 4.3% estimate from the government and above the 3% European

Union threshold for excessive deficits (EUROSTAT, 2016). Moreover, in 2016 Portugal's modest GDP growth is expected to slow down again, as the consumption-driven recovery loses its momentum, and the country's stock of corporate debt remains one of the highest in the EU (Rumney, 2016).

As a regulator, ERSAR has also to recommend tariffs to the local operators. However, the latter are the ones that have the final word. The main problem consists in that these entities have political incentives to advocate lower tariffs in order to promote the electorate. As a consequence, their financial statements result untruthful and the tariffs set by the regulator become ineffective. Nevertheless, ERSAR has to consider also the difficult Portuguese economic situation and the pressure put from the European Commission when double-checking EGs' financial statements and revising the tariff-setting process. Therefore, the CEMS team proposes a financial model able to set benchmark costs for different typologies of municipalities and to detect any under/over estimated cost. Moreover, this model enables ERSAR to asses and compare EGs performance through a comparison of their internal indicators with an international reference.

b. Methodology

The work done is divided into three phases: Diagnostic, Analysis and Recommendations. During the first phase, three main sources of information have been exploited. The begin with, a thorough research on the overall industry has been carried out. Materials from ERSAR's website, from international organizations' ones and data from the major global trends research institutes have been scrutinized. As a second source of information, ERSAR's experts have been interviewed and the major industry trends and economic difficulties have been discussed with them. Finally, a player in the industry has been consulted. Six full days have been spent by the CEMS Team visiting *SIMAS Oeiras e Amadora*, because of being considered a "best

practice". They shared many useful insights both regarding their internal operations and about their view on the global industry trends.

The analysis phase consisted in gathering data from ERSAR's database and running statistical analysis. Using the SPSS software, several analyses have been run to test the hypothesis that lies at the base of the Business Project, which consists in finding evidence that costs vary among EGs according to some specific characteristics, in order to extract a single operator that can represent the best practice of that particular group. Then, according to the results obtained from the abovementioned analysis, and implementing the suggestions of ERSAR's experts, a financial model has been drafted. Using Microsoft Office Excel, all the data has been homogenized and inputted into a spreadsheet, from which the model would gather and report all the information.

The recommendation phase concerned summarizing the findings of the analysis and suggesting ERSAR how to proceed next. These suggestions entailed, among others, a deeper view and interpretation of the financial model's output. Moreover, as regulators, they need to proactive consult the operating entities regarding how to further develop their strategies and become more efficient. The main goal was to increase the reliability of the data by all EGs, in order to set tariffs according to the real costs incurred by these entities. In turn, ERSAR will eventually contribute to the reduction of abuse of public spending by making the EGs economically sustainable.

i. Hypothesis

The main sources of primary information regarding the industry and the daily activities of the operators, have been the multiple meetings with *SIMAS Oeiras e Amadora*. At the very beginning of the project, a full week has been dedicated to the thorough understanding of the public water sector and all its facets. The meetings have taken place with the following

departments: human resources, communication and customer service, information technology, tele-management and equipment, losses and mapping, infrastructure, accounting, and legal and auditing. From these meetings, among others, it emerged that the Portuguese Water and Wastewater Management sector is highly fragmented. It is indeed composed by numerous operators that vary in terms of scale, operations, geographic location, client base, efficiency, degree of digitalization, management models, etc. All these entities' financial statements are different and the costs allocated to each item vary. Moreover, while some costs are considered to be fixed, so do not vary with scale, many are variable, which means that depend upon other variables.

It has been long discussed about the source of the variable costs and it became extremely complicated to compare each cost item of such different entities considering all their attributes. Given all these disparities it has been hypothesized that the operators could be grouped based on a defined set of characteristics, and that the costs would vary among the groups. The scope was to then extract one single entity per group, that could be used as reference, to make intragroup comparisons. More specifically, the hypothesis wants to test whether any of the groups would have different average costs, and it has been set as follows:

$$H_0: Total\ Costs_A = Total\ Costs_B = Total\ Costs_C = \cdots = Total\ Costs_Z$$

$$H_1: \text{At least two clusters have different } Total\ Costs$$

Where: *A, B, C, …, Z* represent the different clusters and *Total Costs* is the sum of the *AA* and *AR* costs that, based on the specific cluster analyzed, will be accounted for.

The attributes selected for the cluster analysis are:

1. Scale: it is summarized by the categorical variable that combines two information, namely the population density of the area of its operations and the total population. The variable can assume 3 values, namely *Urban*, *Semi-Urban* and *Rural*.

2. Vertical integration: it is summarized by a dummy variable that describes the type of operator. It can either be both a Bulk and Retail operator or only a Retail one. In the former case it is considered as *Verticalized* while in the latter, it is considered as *Non-Verticalized*.
3. Horizontal integration: it is summarized by a categorical variable that describes the activities performed by the EG, which are Water Supply (*AA*) and Wastewater Management (*AR*). It can take 3 values, namely *Only AA*, *Only AR* or *AA+AR*.
4. Management model: it is summarized by a categorical variable that explains how the operator conducts its operations. It can assume six values, categorized into three macro ones, namely *Delegation*, *Concession* and *Direct Management*.

ii. Analysis

The Creation of Clusters

To test the hypothesis, clusters have been created by grouping municipalities based on a set of common characteristics. The clusters have been defined in order to minimize differences of those attributes among observations within each cluster while maximizing diversity among groups. The aspects taken into consideration are split into two types: the ones suggested by ERSAR and the one chosen based on a statistical analysis. ERSAR has expressed his interest in first separating EGs according to the activities they perform, namely Water Supply (*AA*) and Wastewater Management (*AR*). Therefore, the municipalities were divided into three groups: *Only AA* (8 obs.), *Only AR* (15 obs.) and *AA+AR* (248 obs.). Secondly, ERSAR asked to further separate municipalities based on them being responsible for both bulk and retail operators or only retail. Because of the difference in size of the first three clusters, only *AA+AR* has been further split into *Verticalized* (46 obs.) and *Non-Verticalized* (202 obs.).

While the previous groups were not backed up by any analysis, but only ERSAR recommendations, the next criterion has been statistically tested. The variable used for the analysis is *Total Costs* (relative only to *AA* and *AR* activities), and it has been tested only among *Verticalized* and *Non-Verticalized*. This variable has been tested to detect differences in costs among different *Typology of Area of Intervention*. This variable is divided into three levels: *Urban, Semi-Urban* and *Rural*. Each level is categorized by a weighted combination of the population density and the total population in that area (see **Appendix 3**). Therefore, an *independent samples t-test*[1] has been run testing whether there were statistical differences in average *Total Costs* among every combination of typologies of area.

It has been found out that within the *Non-Verticalized* all the clusters report statistically different *Total Costs* among each other at a 95% level of confidence. Different is the case for the *Verticalized*, in which it has been found out that, on average, the *Total Costs* of the clusters *Urban* and *Semi-Urban* are not significantly different from each other (*p-value* = 0.140 > 0.05). Therefore, these two clusters have been merged and another *independent samples t-test* has been run, to check whether there was a significant difference in *Total Costs* between the newly created cluster and *Rural*- within the *Verticalized*. It has been found out that they are statistically different with a 95% level of confidence.

Concerning the management models, the same tests have been run, to check if there were statistical differences in costs according to the different type of administration. None of the *t-test* reported significant results, meaning that on average the costs can be assumed not to vary according to typologies of management implemented. Therefore, taking into consideration both ERSAR's suggestions and the results of all the statistical tests run, in total 7 mutually exclusive and collectively exhaustive (MECE) clusters have been created (see **Appendix 4**).

[1] This test compares the means between two unrelated groups on the same continuous, dependent variable (SPSS).

The Ranking Criteria and Benchmarking

The next step consisted in identifying and extracting a benchmark operator within each cluster. It served as a reference to be compared with all other EGs within the same cluster. To build a model that could easily be updated every year, it has been decided to use only variables that were already existent in ERSAR's database The possibilities considered for the selection method included the calculation of the arithmetic average of all operator costs for each group, the weighted average of the 3 most efficient EGs or the selection of the lowest total costs. However, the main common issue faced in all these methods was the low reliability of the data, which made every ranking untruthful and biased. Moreover, only a quality measure was not precise enough to select a certain operator as a Benchmark for each cluster. Therefore, it has been decided to include also an indicator of reliability. This has been found under two variables that have both been included in the calculation. The final score has been calculated as a weighted average of three indicators:

1. Regulator assessment: this indicator is constituted by the arithmetic average of the quality of all the indicators. The evaluation is done by ERSAR. Each value ranges from 1 to 6. However, the values 4, 5 and 6 have been excluded from the analysis, since they represented errors- either missing or not applicable values.
2. Regulator's reliability score: this indicator is represented by the arithmetic average of the reliability of all the indicators. Also this one is directly assessed by ERSAR, and each indicator's value range from 1 to 3.
3. Auditor's ranking: this indicator is available only for some EGs, and therefore will be considered only in certain cases. The evaluation is done by an external entity, which measures the internal accounting system. Each value range from 1 to 6 and have been divided into three groups to adapt to the previous scale[2].

[2] The grouping system is as follows: 1 and 2 had value 1; 3 and 4 had value 2; 5 and 6 had value 3

After a detailed discussion with ERSAR's experts, a mechanism that would summarize all this information and would also meet the regulator expectations has been chosen. It consisted in a weighted average to calculate the ranking that took into consideration all three variables only for the operators in which an external audit had been done. More specifically, one third of the weight has been attributed to each parameter. For the cases in which the external audit had not taken place, only the first two parameters have been considered, with a respective weight of one half each. These calculations led to a final score for each EG that ranged between 1 and 3. Subsequently, this score has been used to create rankings of all the operators in each cluster. Then, within each group, the EG with the highest score has been selected as best practice.

Cost Analysis

After having clustered all the EGs and selected the best practices, it was time to put everything together into a model that could automatically extract and compare all the cost items between any chosen operator and the benchmark of its group. With an automatic Macro in Excel, it has been possible to combine all the financial statements into one single document and to integrate it into the model. Then, only the most relevant cost items, divided by the *Volume of Activity* and split between *AA* and *AR*, have been selected to automatically appear and be compared among EGs.

The front screen of the model has been divided into four sections (see **Appendix 5**). The first one shows the benchmark cost values as they are in Euros per cubic meter. The second one shows the benchmark unit costs multiplied by the activity of the EG selected, so to show how the real costs should be in Euros. The third one shows the unit cost of the EG selected and the fourth one shows the operator costs are they are presented in their financial statement. However, it is possible to manually select the best practice for each cluster, if one feels the need for a different comparison.

When selecting the EG to be analyzed, the various cost items will be highlighted in yellow to show which ones represent the highest share of the total costs. Meanwhile, each cost value will assume one of three colors: green, orange or red, according to its variance form the benchmark value. The thresholds have been set as follows: Green indicates that the EG's cost item is between 90% and 110% of the benchmark; Orange indicates that the cost item is between 90% and 50% of the benchmark; Light orange indicates that the value is between 110% and 150% of the benchmark; Dark red indicates that it is 50% or below the benchmark (undercosting); Light red indicates that it is 150% or above the benchmark (overcosting). Nevertheless, these four percentage intervals can be manually changed (see **Appendix 6**).

Performance Analysis

Another section of the financial model is dedicated to the analysis and comparison of performance indicators. For this analysis, in addition to ERSAR's database, the European Benchmarking Co-operation's (EBC) Public Report has been consulted. The benchmarking program is accessible to all types of water utilities in 17 countries[3], and EBC supports all the participants in collecting high quality and reliable data. This part of the model is divided into three sections, each split between *AA* and *AR* (see **Appendix 7**). The first one reports the performance indicators' values of the EG selected. The second one shows the values of the benchmark of the cluster in which the EG selected is, and the third one shows the values of the International Benchmark (IB).

The study of the IB involved several activities such as a thorough study of the international organizations, their different economic situations and their diverse management styles. For instance, the operator Vivaqua in Brussles, has been analyzed and some meeting were arranged to get some external views and opinions about the industry trends and their specific strategies.

[3] Belgium, Cyprus, France, Germany, Italy, The Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, Switzerland, United Kingdom, United States, Japan and Republic of Singapore (European Benchmarking Co-operation, 2015).

In the extraction of the IB values, 43 utilities have been taken into consideration. Since all these had different size and were, on average, bigger than the Portuguese operators, only the median value has been taken as reference. Moreover, the values are all calculated per unit, so to be comparable also among different scales.

When selecting the EG to be analyzed, a measure of costs' reliability will appear in the form of a dot. It can assume three different colors, according to the number of cost items in which the EG scored less than 50% compared to the benchmark: Red correspond to more than half of the total items; Yellow means half of the items; Green corresponds to less than half of the items. Moreover, also in this model a color scheme highlights the most significant deviations from the benchmark. The indicators shown are of two types. On the one hand, the performance indicators, in which a greater value represents better performance. On the other hand, the economic indicators, that consist of values that should be around the same level as the best practice. The low values in the first case and the ones distant from the benchmark in the second case are shown in red. Green is instead used if the values are either high-in the first case, or close to the best practice- in the second case. Finally, yellow is shown if the values are in a midway either in terms of absolute value or distance from the benchmark. The specific thresholds can be manually changed, according to one's preferences (see **Appendix 8**).

Cross-Clusters Comparison

In order to deepen the analysis and to be able to make comparisons among EGs of different clusters, an extra tool has been developed. In a new table it is possible to select and compare cost items among six EGs from any chosen cluster (see **Appendix 9**). More specifically, an automatic updated chart will summarize and show the details of the *Cost of Goods Sold and Materials Consumed*, *Supplies and External Services* and *Personnel Costs* with an indicator of the total *Volume of Activity* for each operator, split between *AA* and *AR*. Furthermore, a set of

charts will plot average *Supplies and External Services* and *Personnel Costs* as a function of any chosen variable that represents scale, as for instance *Volume of Activity* or *Number of Clients* (see **Appendix 10a-b**). This analysis could facilitate ERSAR in identifying costs subject to economies of scale.

c. Recommendations to ERSAR

Recalling the null hypothesis, which was testing whether all clusters would show no differences in average *Total Costs*, it can be concluded that it has been rejected. It means that, as shown in the analysis, the average *Total Costs* is statistically different across at least two clusters, based on the type of area of intervention, on being verticalized or not and on the activities performed. However, total costs have shown not to vary significantly relative to the management models, which has then been excluded from the model.

According to the results of the statistical analysis and taking into consideration all the concerns about the financial model, which will be discussed in the next section, ERSAR can be facilitated in the identification of the EGs with presumed misallocation of costs. Once these errors are found, it becomes possible for ERSAR to disseminate best performers' practices among other EGs, so that they can better understand how the first-rated municipalities operate and can reshape their operations accordingly. The scope is to then propose to these EGs strategies that would assist them in correcting the allocation of costs, increasing their operational efficiency and foster cooperation among municipalities to share knowledge and technology. The successive step for ERSAR would be to adjust the respective tariffs- case by case, by calculating the ratio "Coverage of Total Costs" over the best practices' costs, in order to make sure that the tariff is set according to the real costs of each municipality.

d. Concerns

It is necessary to bear in mind the limitations of the model when estimating EGs' costs. The first set includes the constraints imposed by the data itself. It has been necessary to exclude from the analysis all the municipalities of which data were missing. Moreover, since the data used is from 2014, it may lose relevancy for the benchmark. This is why it becomes crucial to constantly update the dossier and create an incentive system to make sure that all the EGs will provide the required information as accurately as possible, so to minimize the inter-inconstancy. Furthermore, in few cases the variables showed different unit measures among municipalities and/or against the international benchmark, causing difficulties when comparing values.

The second set of restrictions is related to benchmarking. It is vital to keep in mind that the selection of the municipalities used as reference comes from a statistical analysis. It includes a margin of error that originates from the small sample size, the difference in dimension among the clusters, and the non-perfectly normal distribution of *Total Costs* (see **Appendix 11**). Furthermore, to group municipalities, apart from the arrangement given from ERSAR, only a defined set of attributes of the EGs has been used. Therefore, some specific aspects of each municipality's cost structures have not been included. Within these characteristics, *Verticalized* reported some issues, since the discriminant factor was if the EGs bought any water in *Alta*. Therefore, even if the municipalities that are *Verticalized* but bought a little amount of water, have been categorized as *Non-Verticalized.* Finally, regarding the international benchmarking, it is crucial to keep in mind that the values extracted and selected are the median ones, which might not be accurately compared to the EG selected. To avoid this, a scalable algorithm can be created that adjusts these values based on the specific characteristics of the municipality under consideration.

e. Individual contributions

The team was composed by four students with three different nationalities, of different ages and with diverse academic backgrounds. This diversity posed a first challenge to the group, that decided to run the Myers-Briggs Type Indicator (MBTI) personality test to get to know better the other members even before starting the project. From the results of the test, it came out that this diversity, instead of posing a threat, could enable the team to embrace all the aspects of the challenge by having diverse points of view on the issues. Considering the different backgrounds and the skills developed through the studies, it had been collectively decided to appoint me as the responsible for the statistical analysis. The discovery and selection of the variables to be used in the investigation were driven by the group's understanding of the sector dynamics together with the insights and feedback given by both ERSAR and SIMAS's experts.

Being in charge of the statistical part, it was necessary for me to actively participate in most of the meetings with SIMAS, all held in Portuguese, in order to better understand how to build and develop the analysis. After having understood how the operators differ among themselves in terms of organizational structure and operations, I was ready to start the analysis. Therefore, a meeting with ERSAR had been scheduled, in which their first request was to split the operators according to two variables that they considered crucial for the cost structure, namely the activities they perform (*AA* and *AR*) and being *Verticalized* or not. Therefore, the first groups were made. Then, I wanted to understand which were the main operators' cost drivers in order to focus my attention only on those. To begin with, it was necessary to collect all the data available from ERSAR's website. On their portal, only the aggregated data was available, meaning that the costs were not split in separate items. While waiting for ERSAR to send us the disaggregated ones, to be used in the final model, I started running the analyses using the variable *Total Costs*, composed by the sum of *AA* and *AR* expenses only.

I drafted two charts with *Total Costs* on the vertical axis and both *Volume of Activity* and *Number of Clients* on the horizontal axis. Both, even by being based only of part of the population because of missing data, gave the hint that there was a positive relation (see **Appendix 12a-b**). However, the volume of activity was not the best indicator to represent scale, since it did not take into account the length of the pipeline. Basically, it could not differentiate among two entities selling the same amount of water but one having to reach many clients far away, incurring in more infrastructure costs, and the other having only one big client very close by. The number of clients instead, would not take into consideration the density of the population, meaning that it could not differentiate among an entity serving 1,000 clients highly dispersed and another one serving 1,000,000 but all concentrated in a small area. Therefore, the information missing was the total length of the pipeline, not available in ERSAR's database, and/or the client density in a specific area.

After getting the disaggregated data, to understand which could be considered fixed versus variable costs, I started checking how the cost items varied across operators and how they were related to the volume of activity. Essentially, I calculated the correlation coefficient between each cost item and the *Volume of Activity* across EGs (see **Appendix 13**). From this analysis, and cross-checking the results with SIMAS's Information Technology department, it emerged that most of the costs incurred by operators could be considered variable. It meant that they varied according to the number of clients, the kilometers of pipeline and/or the volume of water sold, sustaining what already saw in the previous analysis. Therefore, I had to find a way to discriminate operators using this source of cost difference.

After discussing about these results with ERSAR's experts, we agreed on taking into consideration the *Typology of Area of Intervention* in the analysis that, as explained earlier, considers both the density of the population in a specific area and its total population. This variable resulted to be positively correlated to *Total Costs* with a value of 0.629 significant at a

99% level of confidence (see **Appendix 14**). Therefore, after having recoded the three typologies of areas into single dummies, I run a *linear regression*, since it assumes that the relationship between the dependent variable and the independent ones is linear. Moreover, this relationship is modeled through an error ε, which is an unobserved random variable that adds noise to the linear relationship. The regression has been run as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where *Y* corresponds to *Total Costs* and *X* represent the dummies, one of which has to be kept out of the model as a reference. The parameters β_0, β_1 and β_2 are constants describing the functional relationship between the variables. The important value to consider is the explanatory power of the model (R^2), which showed a value of 49.9%. This means that about half of the variation of *Total Costs* is explained by *Typology of Area of Intervention*.

Satisfied with these results, I started analyzing the variation of *Total Costs* among EGs within the clusters previously made together with ERSAR, to then eventually create sub-clusters. I decided to run was the *independent samples t-test* because the populations of the groups are independent and have unequal sizes and variances. The test is calculated as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{X}_1 - \bar{X}_2}} \qquad \text{where} \qquad s_{\bar{X}_1 - \bar{X}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

$s_{\bar{X}_1 - \bar{X}_2}$ is the unbiased estimator of the variance of the two groups, n is the number of observations in each group (1 and 2) and $n - 1$ is the number of degrees of freedom for either group. For use in significance testing, the distribution of the test statistic is approximated as an ordinary Student's t distribution[4]. As previously outlined, there have been successfully found differences among groups of municipalities based on the three criteria chosen, creating the final 7 clusters. After having completed the analysis, the data manipulated have been introduced into the model and used to split the various EGs into their respective clusters of belonging.

[4] The degrees of freedom are calculated as follows: $\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2 / \frac{\left(\frac{s_1^2}{n_1}\right)^2}{(n_1 - 1)} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{(n_2 - 1)}$

3. Academic discussion

a. Link with the Management Field

In the modern world of increasing developments in information technology, the amount of numerical data available has increased tremendously and the acquisition of knowledge has never been so accessible (Marvin, Chappells, & Guy, 1999). In such a complex and highly regulated sector which is facing a crucial transformation towards digital systems and in a country that is facing an economic downturn, how can organizations survive? Can they overturn the macroeconomic situation and improve their operational efficiency in terms of management practices and cost reduction? To further discuss this dilemma, the Quantitative Approach to Management is depicted. It develops from ERSAR's role of regulator and controller that aims at unveiling misallocations of cost items in order to set the tariffs accordingly. Moreover, this section provides an academic reflection on the key strategic alliance method relevant in the public water industry, which could be necessary for the EGs to increase their operational efficiency thus reducing their real costs.

b. Relevant Theories and Empirical Studies

i. Quantitative Management and Global Transparency

As explained by Carol Wood, former mathematician and professor at Berkley, University of California, quantitative methods provide different approaches to exploit this growing accumulation of data as support for strategic governing. In particular, the Quantitative Approach to Management blends a multitude of analytical and numerical techniques into management methods. The scope is to create specific formulas that information can be plugged into to provide the best answer to common management questions (Woods, 2016). More in specific, among the three areas considered part of the quantitative management, the most relevant for this discussion is the Management Science. This area was discussed already in 1969

after Kenneth R. Baker, former applied physics student in Harvard University, received a Ph.D. in operations research. This specific area applies mathematical models and statistical techniques to management decision making. Moreover, this approach enables organizations to predict future outcomes of management decisions with accuracy (Baker & Kropp, 1985). Indeed, these mechanisms, that create simplified representation of a system, process, or relationship, will reveal to be key for succeeding in the Public Water and Wastewater sector.

All the stakeholders operating in the water sector have voiced the need for better measuring and reporting on water supply demand trade-offs (Forer & Staub, 2013). As seen also in the Portuguese market analysis, the deficiency of standard measures and transparency in costs erode the eventual cooperation among municipalities, which in turns prevent effective water governance (Birrell, Rapson, & Smith, 2005). As it became evident in the implementation of the International Benchmark in the model, Portuguese water accounting lack common standards and practices, and only little is audited by independent third parties. Moreover, many municipalities do not possess an updated and detailed analysis of the state of their infrastructure. Consequently, they are being operated at sub-optimal efficiency levels. However, Portugal is not the only country suffering, since this is a global trend that is mining the global public water industry (Forer & Staub, 2013).

ii. The Technology Driver

The challenge is to establish a common global benchmarks and to select key comparable metrics that drive efficiencies across all EGs in order to ease knowledge exchange. A homogenization of standards and rational model testing are required to select best practices and to support cross-sectors or cross-municipalities sharing of data and technology (Neenan & Hemphill, 2008). Indeed, new technology systems not only enable better measurement, but also help institutionalizing quantitative management of water systems. *SIMAS Oeiras e Amadora*

represents an excellent case in which demand-side management initiatives, such as the implementation of an advanced informatics system, though having required an immense investment in the short term, have generated tremendous cost savings in the long term. According to an expert in advanced environmental technologies, system innovations may produce cost savings of upwards of 20% (Accepta, 2002). These new engineering knowledge and technologies could lead to substantial transformation on how the water systems are constructed and managed (Forer & Staub, 2013).

Long-term benefits would include an effective and integrated data-driven management system that reinforce advanced asset allocation and therefore decision-making. Indeed, these are expected to reduce costs in terms of energy consumption, monitoring water quality, an extension of the useful life of the infrastructures- decreasing amortization, and a reduced capital expenditure by managing peak demand (Stewart, Rodney A., et al. 2010). This holistic approach stands out from the need for cross-agency collaboration and proactive engagement of all stakeholders in joint management processes (Gleick, 2011).

iii. An Update is Needed

It seems clear that investments in water infrastructures, innovative technologies and new approaches are critical. So far, according to The American Society of Civil Engineers the main institutional changes have taken place due to financial distress, operational necessity and innovations in other industries (ASCE, 2012). Therefore, a more quantitative and transparent approach regarding both operation and management systems would ease precise measurements that in turn could improve the quality of costs allocation. Moreover, quantitative management would stimulate innovation by introducing higher quality standards, all of which are requirements to a crucial change (Glassman et al. 2011).

In Portugal, some municipalities are already setting up resources and systems to empower dialogs among all the local stakeholders- from customers to the Government, as for instance represented by the case of SIMAS. They are transparently sharing their knowledge to guarantee the correct implementation of sustainable and appropriate locally-tailored solutions. Indeed, also the role of the regulator is changing. While being mainly a controller entity, it is now aiming at better understanding the costs of different alternatives, that could facilitate the creation of a simplified yet more efficient water market. Moreover, as explained in an interesting publication on Forbes, in the wake of a global economic downturn, that implies stringent capital expenditure plans and higher debt costs, water companies have progressively swung to consolidation and partnership strategies (Kho, 2012).

iv. Consolidation through Public-Public-Partnerships

In the US, in light of a shift towards a more dynamic public water market, a great movement towards consolidation is taking place. In fact, as reported in a study from Cornell University (2012), neighboring small and midsize municipalities are forging partnerships in order to achieve economies of scale and mitigate rising costs. By working together, these entities are able to share resources and costs, leverage shared infrastructure, share investment risks and better exploit their unused capacity. Most of these approaches are based on a Public-Private Partnership (PPP), which promise increased investments and efficiency. However, as underlined by The Organization for Economic Co-operation and Development (OECD) in a report on Pricing and Financing, privatization has often failed to meet these expectations (Warner, 2009). Indeed, by putting public needs into the hands of profit-seeking organizations, often times it has led to deteriorating infrastructure, service disruption and higher prices for poorer services (Craig, 2009).

A different model resulted to be more effective for providing such services. Differently from privatization, a Pubic-Public Partnerships (PUP) brings together public officials, workers and communities to provide better service for all the stakeholders involved by operating more efficiently (Hall, et al., 2009). Being a public collaboration, no PUP partner can generate profits exploiting the cooperation. Therefore, PUPs provide the collaborative advantages of private partnerships without the profit-extracting focus of private operators (Lobina & Hall, 2006). This form of integration allows two or more public water utilities or non-governmental organizations to leverage their common capacities and share their technical expertise. In turn, the benefits of scale and shared resources can deliver higher public efficiencies that lower real costs (Cornell University, 2012). These public partnerships also improve and promote public delivery of water through sharing best practices. The reason behind the fact that they work so well, as summarized from a Principal Economist PhD student at Pacific Institute, is that they retain local, public control of existing water systems (Wolff & Palaniappan, 2004).

v. A Crucial Research Gap

Taking a helicopter perspective, it is vital to remind that while on the one hand it sounds reasonable for EGs to undertake such an innovative process, on the other hand the Quantitative Approach to Management is based on the assumption that the data used in all these models is both truthful and reliable. However, data reliability is exactly the issue that ERSAR is facing at the moment, so jumping to the conclusion that the implementation of such predictive models could improve the situations of the municipalities, might be hazardous.

The adventure that ERSAR is undertaking, is caught into a vicious cycle in which data reliability is the key. Improved data quality is needed to make better decisions, and better decisions are needed to improve the reliability of data. Thus, before building models to improve EGs performances and before integrating multiple municipalities under the control of few, it

might be more effective to create new mechanisms that will allow to improve the quality of the information analyzed, so to exit from that vicious cycle. Only when the system will consist only of reliable information the Management Science can step in to help ERSAR in the decision making process.

c. Implications for Theory and Future Research

From this discussion three key arguments emerged. First, it is necessary for organizations operating in the Water and Wastewater Management sector to innovate and catch up with the technological revolution that is taking place in that area. Second, it is advised to take advantage of Quantitative Management Approaches to decision making, taking into account that there are some management problems, especially those that involve human behavior, that cannot be solved mathematically and cannot be modeled. Third, this new knowledge can be implemented in the form of collaboration among municipalities, as PUPs, in order to further enhance technological progress while optimizing processes and minimizing real costs. However, as awareness and discussion of the potential for systemic management grows, so does the realization that much work remains to be done, and in particular, regarding the roots of the data reliability assumption.

All these arguments have to be backed up by an exit from the vicious cycle of data reliability, which can mine the whole process and lead to misguided conclusions. Indeed, it is crucial to fill this research gap before proceeding with the abovementioned strategies. Other fields in which it is suggested to further research, concern the issue of integration and sharing of intangible assets among operators, such as knowledge or best management practices. When discussing about partnerships, it is crucial to bear in mind that the objectives of both organizations should be aligned, and in this case they entail being as efficient as they can, to better serve the public, and be of less of a burden as possible to the local government. As

previously discussed, there is a political interest that could undermine the relationship between the entities, as well as different organizational cultures that could play a big role as well. Indeed, further researches on the implications that diverging political interests might have on PUP agreements, would help organizations to minimize inefficiencies.

4. Personal Reflection

As the semester was approaching its conclusion and the morality of students' life started turning out to be evident, so emerged the need for a pause to re-think over the last two astonishing and life-changing years that will culminate with attaining the title of Master.

a. Personal Experience

More unforgettable than expected, has been the chance given to me by NOVA to meet two completely diverse cultures that added an invaluable learning experience that rises above the mere work space. Other significant contributors to the overall positive achievement of the program have been the plethora of corporate partner skill seminars and the constructive individual and group projects. Not being Portuguese, but already accustomed to experiencing diverse cultures, it has been possible for me to fully exploit every moment of my transition in this country. Nevertheless, my hunger for international experiences combined with the immense network of schools that Nova has, being also a CEMS partner, brought me to visit and learn from colleagues having distinct backgrounds and schools of thoughts. More than the specific topics discussed during the courses taken in NOVA, CBS in Copenhagen and IIM in Bangalore, it has been the context in which they were framed that predominantly contributed to my learnings and inner growth.

vi. Key Strengths and Weaknesses Observable During the Project

At the beginning of the work, after a thorough individual assessment, the group established its members' roles. Accordingly, the role assigned to me consisted in constantly emphasizing the internal deadlines, and making sure that all the milestones were met. At times, it happened that the team became stuck and unproductive, and I failed at my designed activity. More often though, it happened that even rescheduling the group tasks due to impromptu or necessary plan re-arrangements, the team has met its schedule. My pure interest in number crunching and statistics revealed to be crucial for the realization of the model and my passion for discovering unseen correlations eased the whole data analysis. All in all, my ability to adapt to any situation and be successful brought me to where I am now: about to reach one of my life goals of attaining a truly global degree, while being fully aware of what is awaiting me out there.

vii. Plan to Develop my Areas of Improvement

The combined learnings from the global strategies and the foreign businesses courses will always be relevant in developing and implementing international strategies. Looking forward for a career as an international consultant the awareness of global trends, linked with the knowledge of the differences in local demand, will be extremely useful. Indeed, further on field experiences could enhance my cognitive and practical capabilities in multicultural contexts, consistent with the path drawn ahead of me. An extra infusion of entrepreneurial spirit, will inspire an already genuinely curious mind to continue to ask the right questions. Moreover, collective thinking and the sharing of precious knowledge will increase considerably the amount of courage and self-confidence that will in turn enable me to better understand situations involving uncertainty. Therefore, I plan to further enhance my inner and outer competences through collective learnings in a multicultural environment, which could most probably materialize in my next workplace.

b. Benefit of Hindsight

Probably being the most interesting challenge of my master studies, group dynamics resulted to be vital for the realization of the Business Project itself. Not only in terms of people skills, but also of adaptability to settings and times that could suit all members at once. Nonetheless, this immense threat had been softened by the familiarity with the compromise needed in collaborations when aiming at a successful output. This empowered a huge degree of individual independence and created synergies with the Academic Advisor and the Corporate Partner while enabling all the parties involved to interact in a truly formal yet extremely efficient way. In light of this, regarding the organization of the BP meetings, there could be a possible area of improvement. It would be on the arrangement of the meeting with EGs that not all members could attend due to not knowing the local language.

All in all, getting closer to the conclusion of my master studies, it is now time for me to do my best in order to succeed in such a competitive and challenging world while holding high the core values of both the organizations that paved my way to victory: NOVA and CEMS.

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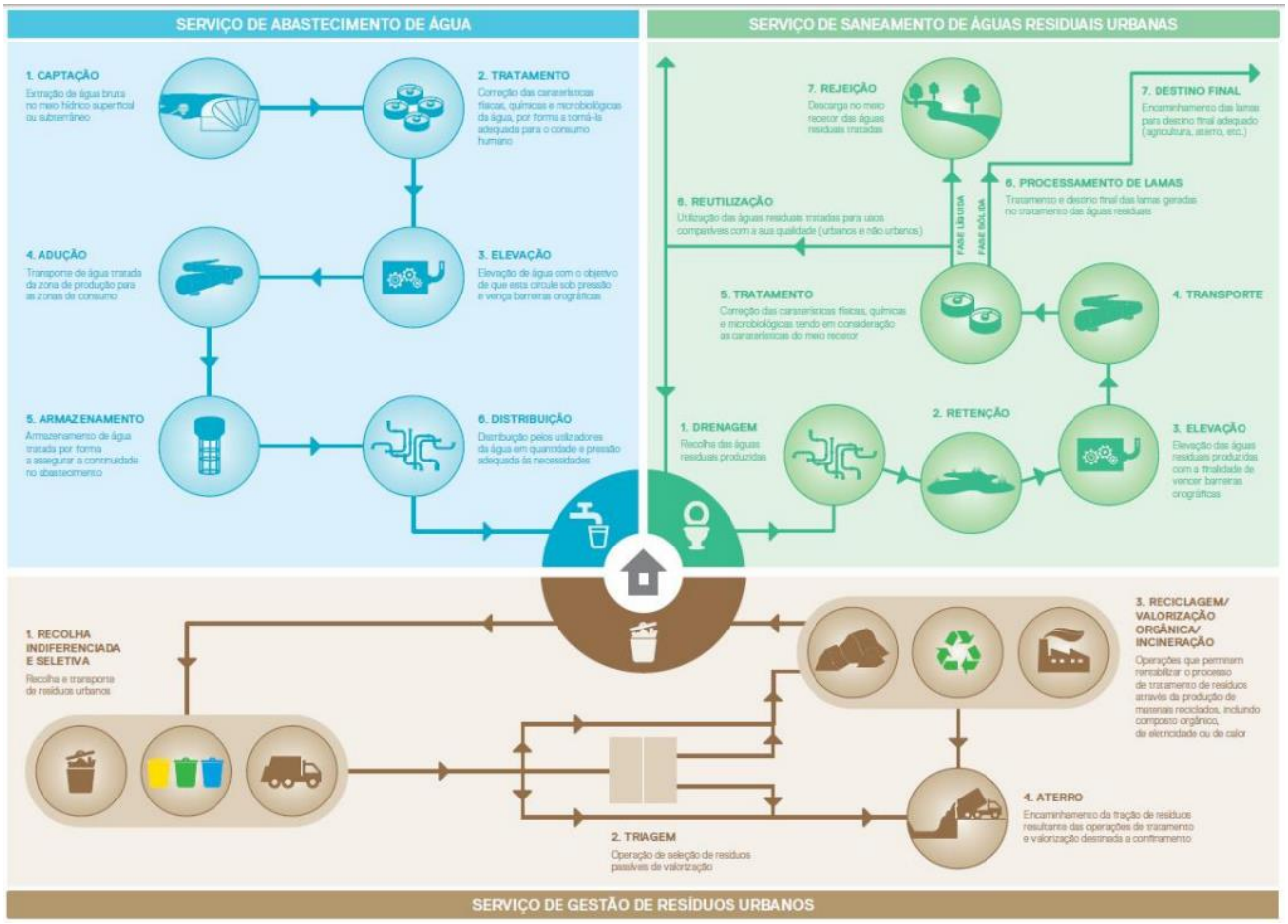
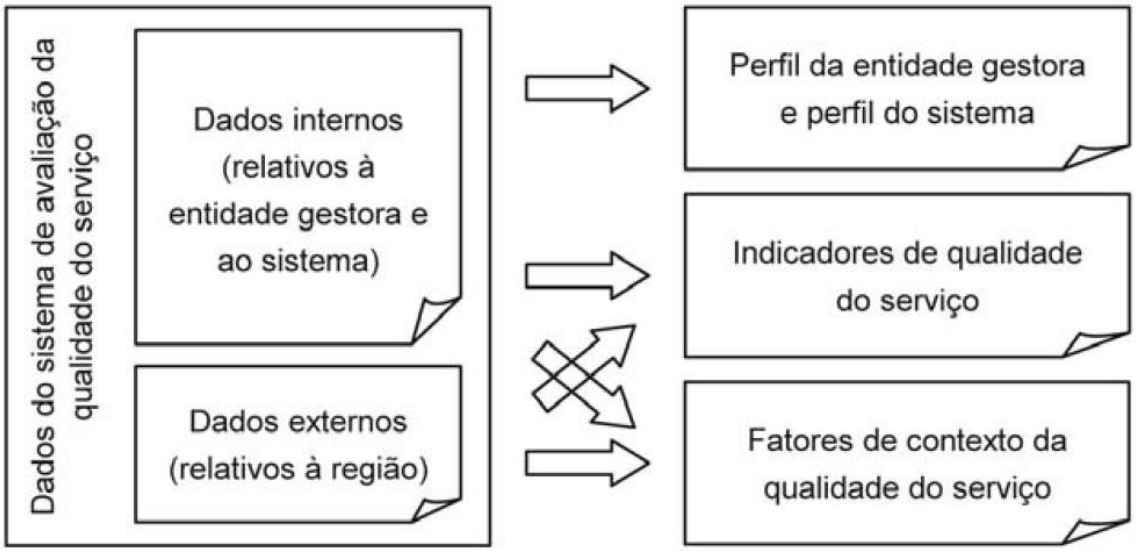
Appendices

Appendix 1 – Water Supply, Wastewater Management and Municipal Waste systems



Source: *ERSAR Report 2016*

Appendix 2 – ERSAR's and Regional Database Integration



Source: *ERSAR Report 2016*

Appendix 3 – Classification of *Typology of Area of Intervention*

Classificação dos concelhos em função da densidade populacional

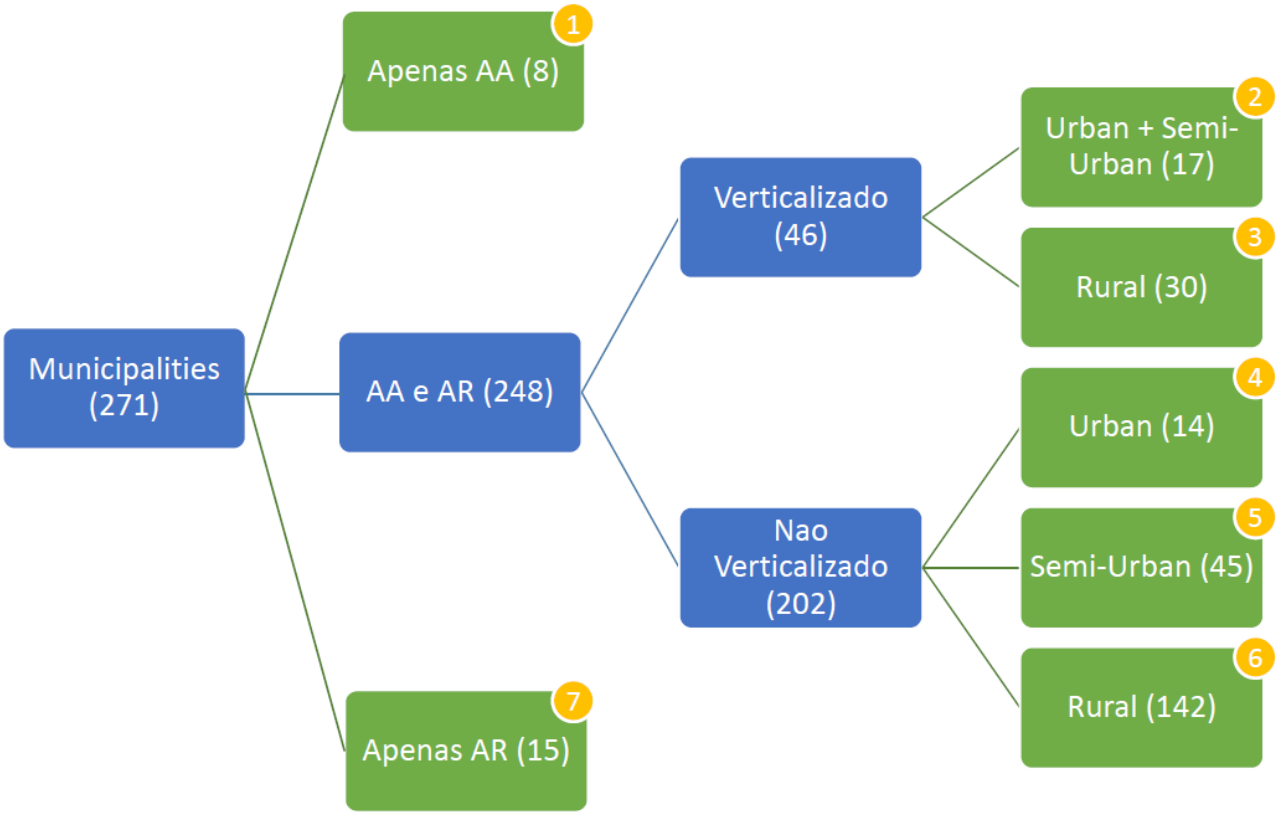
	Densidade populacional (hab/km²)	Tipologia					
		APR		AMU		APU	
Concelhos	< 50	1					
	50 - 100		2				
	100 - 300			3			
	300 - 500				4		
	500 - 750					5	
	> 750						6

Classificação em função da dimensão do lugar mais populoso

	Dimensão (hab)	Tipologia					
		APR		AMU		APU	
Concelhos	< 5000	1					
	5000 - 10 000		2				
	10 000 - 25 000			3			
	25 000 - 60 000				4		
	60 000 - 90 000					5	
	> 90 000						6

Source: *ERSAR Report 2016*

Appendix 4 – Tree Chart of the 7 Clusters



Source: *Business Project*

Appendix 5 – Screenshot of the Cost Analysis Model

ERSAR
ENTIDADE REGULADORA
DOS SERVIÇOS DE ÁGUAS E RESÍDUOS

EG	Águas de Coimbra
Ano	2014

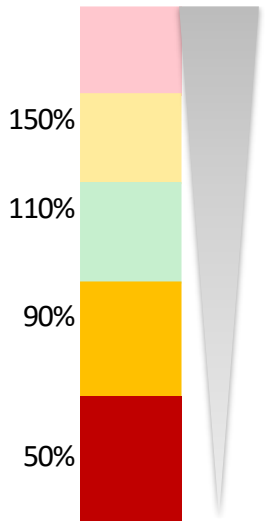
Número do Cluster	5

AA e AR, Não verticalizada, Tipologia Semi-urbano

Rúbricas de Custos	Benchmark SMAS de Tomar				Entidade Gestora Águas de Coimbra			
	Em € por m^3 de atividade		Equivalente para Águas de Coimbra em €		Em € por m^3 de atividade		Em €	
	AA	AR	AA	AR	AA	AR	AA	AR
CMVMC	0.927	0.034	9,081,001	312,480	0.852	0.009	8,351,354	82,953
Custo de aquisição de água em alta	0.881	-	8,629,264		0.843	-	8,261,322	-
FSE	0.184	1.018	1,801,761	9,361,645	0.134	0.662	1,316,516	6,089,509
FSE- Outros FSE	0.035	0.026	345,503	238,995	0.011	0.006	104,458	59,606
FSE-Alugueres de equipamentos	-	-	-	-	0.001	0.001	6,432	5,263
FSE-Combustíveis	0.019	0.014	188,432	130,344	0.008	0.010	77,160	94,233
FSE-Comunicações	0.046	0.034	451,206	312,112	0.040	0.031	394,399	288,920
FSE-Conservação e reparação	0.011	0.008	108,269	74,893	0.024	0.020	236,831	181,511
FSE-Contencioso e notariado	-	-	-	-	0.001	0.001	6,782	5,516
SE-Custo da recolha e tratamento de resíduos em alta	-	-	-	-	-	-	-	-
FSE-Custo do tratamento de efluentes em alta	-	0.882	-	8,115,314	-	0.559	-	5,140,902
FSE-Eletricidade	0.002	0.002	21,823	15,096	0.014	0.007	140,687	67,899
FSE-Honorários	0.002	0.002	21,280	14,720	0.000	0.000	3,218	2,633
FSE-Limpeza, higiene e conforto	0.001	0.001	8,028	5,553	0.000	0.000	2,665	2,181
FSE-Material de escritório	0.004	0.003	37,104	25,666	0.000	0.000	2,587	2,264
FSE-Outros subcontratos	-	-	-	-	-	-	-	-
FSE-Publicidade e propaganda	0.002	0.001	17,851	12,348	0.001	0.001	8,310	6,799
FSE-Rendas de edifícios	0.003	0.002	28,513	19,723	-	-	-	-
FSE-Seguros	0.002	0.002	21,520	14,886	0.004	0.004	43,489	39,495
FSE-Trabalhos especializados	0.056	0.042	552,233	381,996	0.030	0.021	289,496	192,288
FSE-Transporte de mercadorias	-	-	-	-	-	-	-	-

Source: *Business Project*

Appendix 6 – Costs Threshold Values and Best Practices



Cluster	Best Practice
1	Indaqua Fafe
2	Águas da Figueira
3	Águas de Carrazeda
4	Indaqua Matosinhos
5	SMAS de Tomar
6	Taviraverde
7	SMAES de Santo Tirso

Source: *Business Project*

Appendix 7 – Screenshot of the Performance Analysis Model

ERSAR
ENTIDADE REGULADORA DOS SERVIÇOS DE ÁGUAS E RESÍDUOS

EG	Águas de Coimbra
Ano	2014

Número do Cluster	5

AA e AR, Não verticalizada, Tipologia Semi-urbano

Entidade Gestora	Cluster Best Practice	International benchmark
Águas de Coimbra	SMAS de Tomar	

Qualidade e desempenho	EG Valor	Unidades	Cluster benchmark	Unidades	International benchmark	Unidades
Coverage						
Acessibilidade física do serviço	100.00	%	100.00	%	100.00	%
Water quality						
Água segura		%	99,24	%	100.00	%
Reliability						
Ocorrência de avarias em condutas	10.00	/(100 km.ano)	32.00	/(100 km.ano)	14.50	/(100 km.ano)
Perdas reais de água	152.00	l/(ramal.dia)	42.00	l/(ramal.dia)	6.34	m^3/(km.dia)
Service quality						
Reclamações e sugestões	3.98	reclamações/1000 propriedades	0.61	reclamações/1000 propriedades	0.72	reclamações/1000 propriedades
Social sustainability						
Acessibilidade económica do serviço		%	0,68	%	0.64	%
Environmental sustainability						
Eficiência energética de instalações elevatórias		kWh/(m^3.100m)	0,47	kWh/(m^3.100m)	0.49	(kWh/m^3.100m)
Economic sustainability						
Reabilitação de condutas		%/ano	1,2	%/ano	0.55	%/ano
Cobertura dos gastos totais		(-)	1,0	(-)	1.04	(-)
Finance & Efficiency						
Encargo médio com o serviço de abastecimento de água	128.24	€/ano	173.25	€/ano	1.24	(€/m^3)
Adequação dos recursos humanos		/1000 ramais	1,5	/1000 ramais	0.82	/1000 propriedades

Source: *Business Project*

Appendix 8 – Benchmark Thresholds

Color range					
Coverage	**In absolute terms (%)**				
Acessibilidade física do serviço	-	95.00	98.00	100.00	
Water quality	**In absolute terms (%)**				
Água segura	-	95.00	98.00	100.00	
Reliability	**% of the cluster benchmark**				
Ocorrência de avarias em condutas	+	150.00	125.00	-	-
Perdas reais de água	+	200.00	150.00	-	-
Service quality	**% of the cluster benchmark**				
Reclamações e sugestões	50.00	80.00	120.00	150.00	+
Social sustainability	**% of the cluster benchmark**				
Acessibilidade económica do serviço	50.00	90.00	110.00	150.00	+
Environmental sustainability	**% of the cluster benchmark**				
Eficiência energética de instalações elevatórias	+	150.00	125.00	-	-
Economic sustainability	**% of the cluster benchmark**				
Reabilitação de condutas	50.00	80.00	+	+	+
Cobertura dos gastos totais	50.00	80.00	120.00	150.00	+
Finance & Efficiency	**% of the cluster benchmark**				
Encargo médio com o serviço de abastecimento de água	50.00	80.00	120.00	150.00	+
Adequação dos recursos humanos	+	150.00	125.00	-	-

Source: *Business Project*

Appendix 9 – Screenshot of the Comparison Cross-Clusters Model

ERSAR
ENTIDADE REGULADORA DOS SERVIÇOS DE ÁGUAS E RESÍDUOS
Rúbricas de Custos

Comparação entre EGs

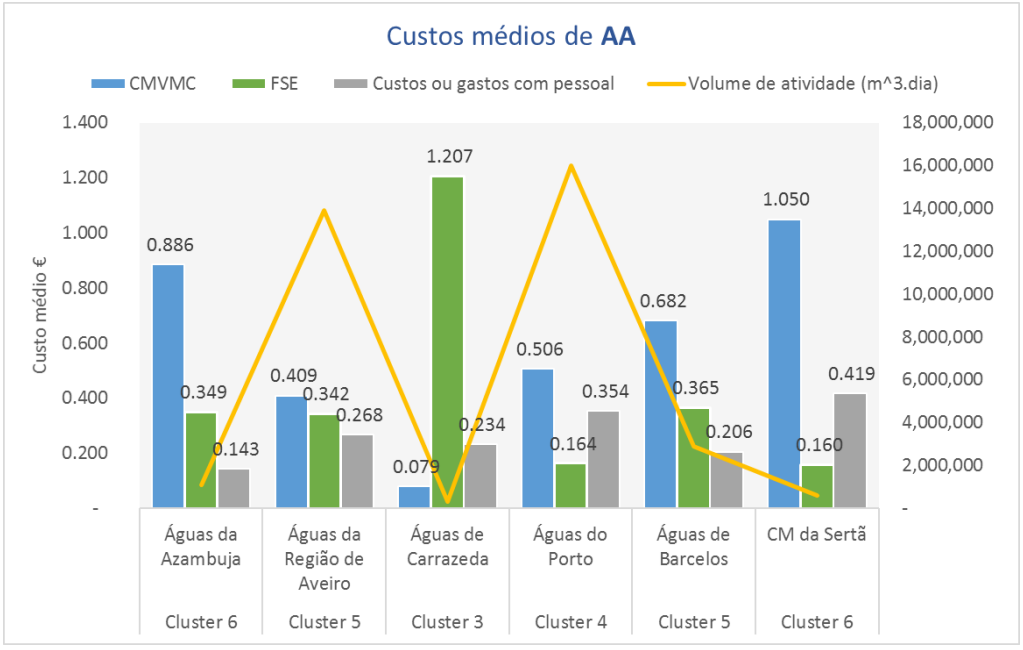
Ano	2014

Water supply activities (AA)

	Cluster 6	Cluster 5	Cluster 5	Cluster 4	Cluster 5	Cluster 6
	Águas da Azambuja	Águas da Região de Aveiro	Águas da Região de Aveiro	Águas do Porto	Águas de Barcelos	CM da Sertã
CMVMC	0.886	0.409	0.409	0.506	0.682	1.050
Custo de aquisição de água em alta	0.875	0.294	0.294	0.483	0.660	1.050
FSE	0.349	0.342	0.342	0.164	0.365	0.160
FSE- Outros FSE	0.022	0.052	0.052	0.019	0.093	0.024
FSE-Alugueres de equipamentos	0.017	0.007	0.007	0.000	0.000	-
FSE-Combustíveis	0.011	0.010	0.010	0.004	0.017	-
FSE-Comunicações	0.046	-	-	0.040	0.010	0.008
FSE-Conservação e reparação	0.013	0.049	0.049	0.003	0.014	0.017
FSE-Contencioso e notariado	0.002	0.005	0.005	0.000	0.008	-
e tratamento de resíduos em alta	-	-	-	-	-	-
o tratamento de efluentes em alta	-	-	-	-	-	-
FSE-Eletricidade	0.016	0.073	0.073	0.009	0.007	0.102
FSE-Honorários	0.002	0.001	0.001	0.003	0.016	-
FSE-Limpeza, higiene e conforto	0.003	0.002	0.002	0.001	0.003	-
FSE-Material de escritório	0.001	0.001	0.001	0.001	0.001	-
FSE-Outros subcontratos	0.078	0.005	0.005	0.014	0.044	-
FSE-Publicidade e propaganda	0.004	0.001	0.001	0.002	0.000	-
FSE-Rendas de edifícios	0.017	0.077	0.077	0.000	0.020	-
FSE-Seguros	0.009	0.002	0.002	0.005	0.006	-
FSE-Trabalhos especializados	0.108	0.056	0.056	0.063	0.123	0.007
FSE-Transporte de mercadorias	0.000	0.000	0.000	-	-	-

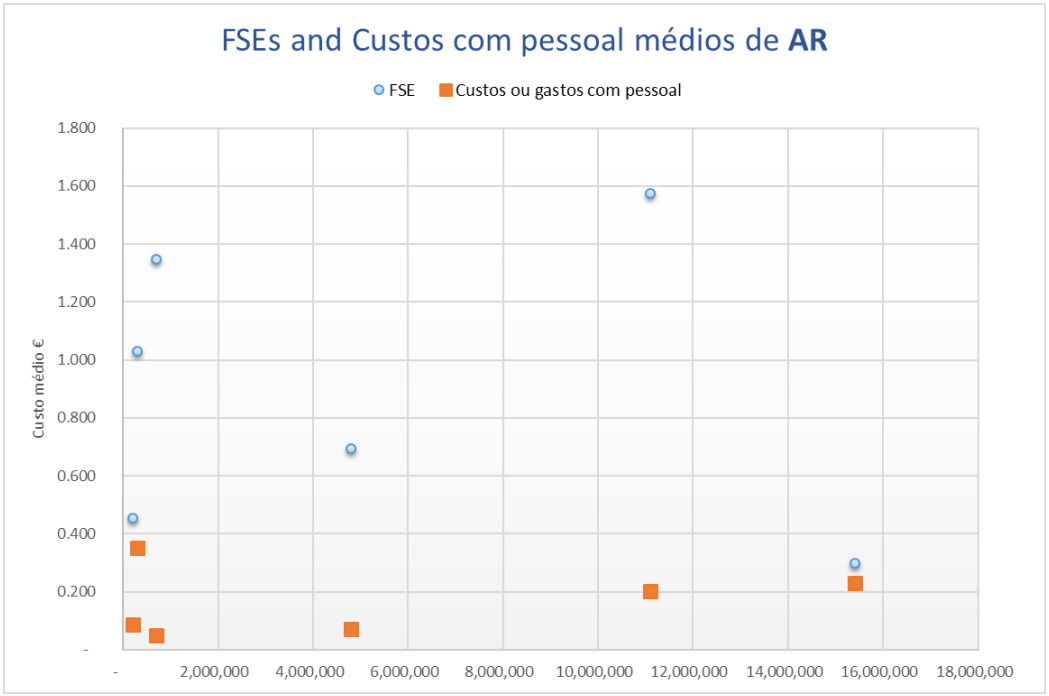
Source: *Business Project*

Appendix 10a – Comparison Cross-Clusters Chart



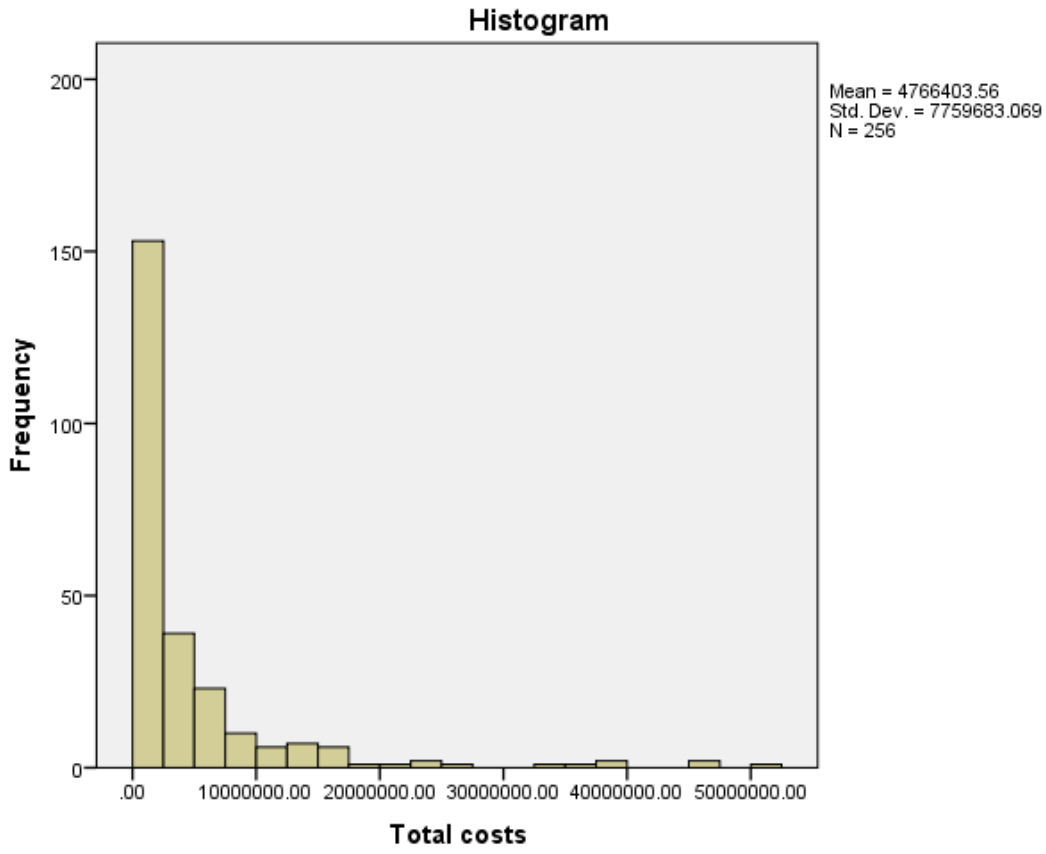
Source: *Business Project*

Appendix 10b – Comparison Cross-Clusters Chart



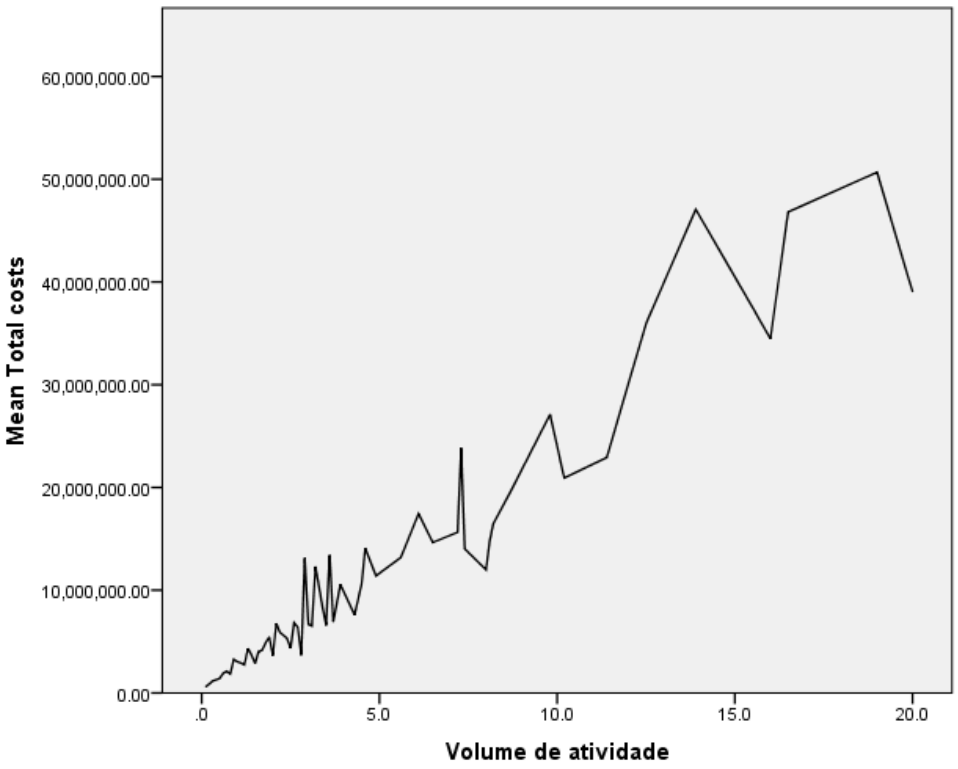
Source: *Business Project*

Appendix 11 – Total Costs Distribution



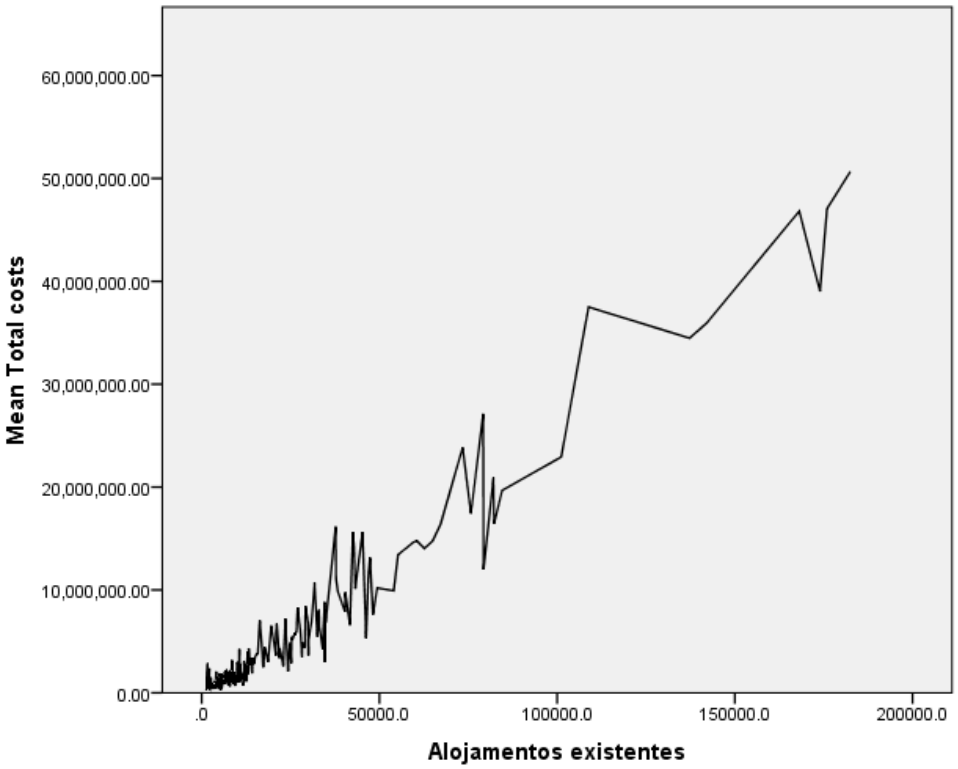
Source: *Business Project*

Appendix 12a – Chart of *Total Costs* and *Volume of Activity*



Source: *Business Project*

Appendix 12b – Chart of *Total Costs* and *Number of Clients*



Source: *Business Project*

Appendix 13 – Correlation Coefficients between *Cost Items* and *Volume of Activity*

Costs	Corr. Coeff.
FSE-Comunicações	0.89381469
FSE-Custo do tratamento de efluentes em alta	0.781078764
FSE-Trabalhos especializados	0.634384246
FSE-Seguros	0.603602717
FSE-Conservação e reparação	0.599707682
FSE-Contencioso e notariado	0.565358282
FSE-Combustíveis	0.529133999
FSE-Alugueres de equipamentos	0.497124435
FSE-Custo da recolha e tratamento de resíduos em alta	0.337792265
FSE-Outros subcontratos	0.301727333
FSE-Limpeza, higiene e conforto	0.258374228
FSE-Eletricidade	0.258108405
FSE-Rendas de edifícios	0.185011167
FSE-Honorários	0.121389534
FSE-Publicidade e propaganda	0.113440104
FSE- Outros FSE	0.062184775
FSE-Material de escritório	0.028755627
FSE-Transporte de mercadorias	-0.040523319
FSE - Total	**0.732524416**

Source: *Business Project*

Appendix 14 – Chart of *Total Costs* and *Typology of Area of Intervention*

Source: *Business Project*