Evaluation of alternatives of goods distribution organization: beverages distribution in Lisbon downtown

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Abstract

The large urban centers are increasingly deserving the interest of the people, it is these centers that are concentrated the commerce and service activities, leading to large population flows and in turn huge needs of supply and distribution of goods and products. As a result cities watch the flow of goods and people increase and they suffer bigger consequences in congestion impact, noise, air pollution, climate change and in turn, loss of quality of life. The transport sector, specifically urban logistics focuses exactly on the study of the supply and distribution of goods in urban areas, taking into account all the specifics and restrictions contained there.

Europe, since the end of the 20th century gave the "kick-off" to the first investigations devoted to the theme of urban logistics. Portugal, more specifically the city of Lisbon, only in the beginning of the 21st century has been paying attention to this subject. Internationally speaking, the whole approach made to this topic has been referenced by city logistics.

This paper is dedicated to the evaluation of intervention alternatives to improve the final phase of beverages distribution in downtown Lisbon. It is proposed a model built for UNICER following a multi-criteria assessment with the MACBETH methodology. On the general balance were identified criteria and descriptors of performance, and seven alternatives were evaluated. The results obtained showed that the most overall attractive alternative is to implement an urban distribution center, which is also the preferred option identified in a cost-multicriteria benefit analysis.

Keywords: urban logistics, final phase of distribution, intervention alternatives, multi-criteria analysis, MACBETH

1. Introduction

The last decades have been marked by intense European transport policy, the result of an increase in the volume of goods transported; recent policies have targeted producers and manufacturers to promote and adopt new technologies for transport means. Nowadays, the main challenge is the establishment of a more efficient use of the resources of modern economies and is therefore required a paradigm shift based on the introduction of new technologies and the development of new solutions (European Union, 2012). Currently, half of the fuel used in road transport is done in urban areas, generalizing the concern for urban logistics. By definition, it is understood as freight transport in urban areas in order to achieve greater energy efficiency and lower CO_2 emissions, keeping the vector quality service. In the global scale, urban logistics has been the subject of several studies and implementations, as being an area of particular interest for those who focuses on supply chains. The urban logistics is a complex theme as various responsibilities are spread by different stakeholders hampering the coordination and consensus of the proposed solutions (TURBLOG, 2010).

The main goal of this work is to identify and analyze problems and impacts related to the supply operations and distribution of goods in urban areas. More specifically, it aims to assess what types of intervention for the final distribution of goods, which the economic operator's point of view involved, best represent their interests. The remainder of this paper is organized as follows. Section 2 briefly describes the case study. Section 3 shows the literature review. Section 4 emphasize methodological proposal for the problem. Section 5 implement the previously proposal and finally, Section 6 discuss and conclude the presented study.

2. Case Study

The case study aims to analyze which intervention alternative makes more efficient freight transport in urban areas and improves their distribution process. Recently, the European Commission found that 40 % of European cities (over 100,000 inhabitants) has not paid attention to this issue, while 60 % acknowledged their importance. The majority of European cities have problems in the transport system to be very efficient and competitive; external costs such as congestion, accidents, noise and air pollution, climate change and other help to identify this problem (COWI; ECORYS; CENIT, 2013). Figure 1 shows the problems.

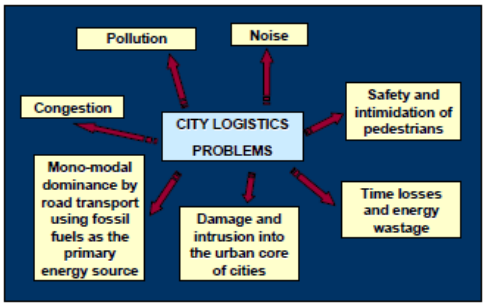

Figure 1 - City Logistics Problems **(BESTUFS, 2006)**

The final phase distribution of goods is considered the most expensive transport operation of any supply chain (Oliveira et al., 2014). Numerous factors may be associated with this high level of costs: high percentage of unrealized deliveries, under-utilization of the total capacity of transport vehicles and impacts related to the congestion of urban centers. The importance of urban logistics grows in finding sustainable solutions to assist in resolving the problem described. The case study will focus on analyzing the type of alternative that will improve the distribution of beverages in urban areas. Lisbon and more specifically its historic center (downtown Lisbon) meet the requisites as urban and UNICER as an economic agent that want to distribute their goods.

The study area is shown in Figure 2 corresponding to the area bordered in yellow. This area was chosen because it represents various logistic realities (heterogeneity) and it is one of the supply zones with greater difficulty for UNICER. The main problems and obstacles identified to the intervention area are (TIS, 2013):

- Historical and tourist district of the city;
- Lack of logistical infrastructure to support;
- High concentration of commerce and services;
- Some restrictions on mobility (Reduced Emissions Zone);
- Inadequate supply of spaces for loading and unloading;
- Cargo spaces and unduly busy unloading;
- High congestion, noise and pollution;
- Existence of reduced hourly windows;
- Regulation of loading and unloading is not fully applied.

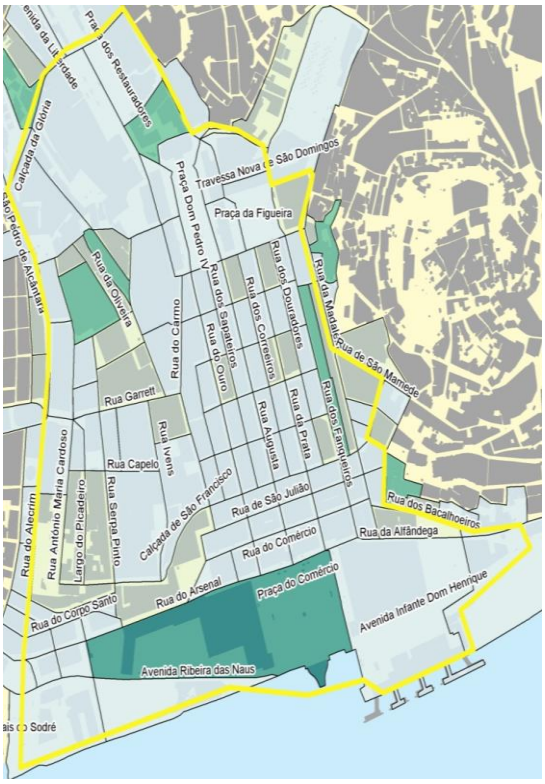

Figure 2 - Study area

To assist in solving the problem will be taken into account the concept of logistics profile, which main goal is to evaluate, accurately, the solutions that best fit each problem / agent (TURBLOG, 2011a). The concept is based upon 3 points:

- City features;
- Needs of the agents involved;
- Products features.

In short, the logistical profile distribution of beverages in downtown Lisbon entails a high frequency of deliveries, requiring some care in handling (fruit weight and fragility of the article) and results even on an operation of loads and slow discharges compared with other products, generating a conflict in an area with narrow streets, large numbers of pedestrians and various restrictions on car traffic.

3. Literature Review

This section presents a thematic framework of the level of the final phase of distribution of goods, intervention and alternative valuation methods to help solve this type of problem.

3.1. Final phase of goods distribution

The transport of goods in urban areas is extremely important to preserve the current lifestyle and provide the respective fundamental economic activities for prosperity (Taniguchi et al., 2014). According to BESTUFS (2006) the concept of city logistics is the key point to address this issue and in accordance with Taniguchi et al. (2010) the notion of city logistics is defined as the process of optimizing logistics and transport activities by private actors in urban areas, considering the impacts in terms of congestion, the environment and energy consumption. In addition it has been found a growth in the number of trucks circulating in the cities, due to the increase in the volume of goods to be distributed, which combined with the technological progress in the production, e-commerce growth and just in time required deliveries, intensifies the problems of urban logistics. The above described trends originate a functional delivery system but inefficient (Reisman, 2011). In the urban transport systems are taken into account four key agents (Taniguchi et al., 2010):

- Central and local authorities;
- Suppliers;
- Consumers;
- Logistics operators;

According to BESTUFS (2006) the critical point in this type of transport is the convergence between the two premises presented in Figure 3.

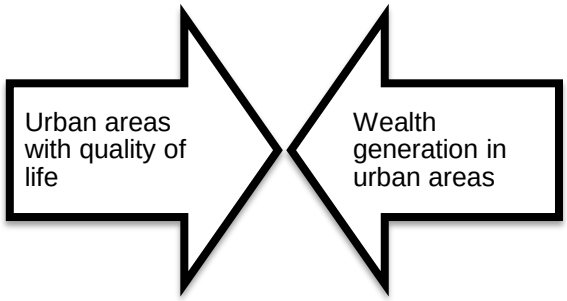

Figure 3 - Conflict of interests in urban areas

3.2. Intervention alternatives

The concept of push & pull was adopted as a guideline of different interventions. A push measure is one that is imposed on logistics operators in order to influence practices, while the pull measures are designed to encourage more sustainable transport of goods by means of incentives. Finally, there is the type of measurement characterized by push & pull, involving a combination of the two types discussed above (C-Liege, 2014). The work is exclusively addressed to interventions inserted under the access vehicle of goods and operations of charges/discharges in urban areas summarized in Table 1.

Table 1 - Intervention alternatives

Intervention	Benefits
Signaling	Improvement of urban mobilization;
Time restrictions	Decreases the conflict entre economical agents and population;
Reduced emission areas	Improvement in the air, noise and congestion quality;
Path/specific bands	Reduction of congestion and accidents;
Charges/discharges areas	Reduction of congestion and accidents;
Night deliveries	Reduction in the number of vehicles and kms, reduction of the fuel consumption;
Alternatives vehicles	Improvement in the air and noise quality;
Inteligent transport systems	Monitor and control the charge/discharge operations;
Center of urban distribution	Value-added solutions in stocks management, delivery operations and reverse logistics;
Freight village	Management of synergies between different operators and companies.

3.3. Evaluation methods

The evaluation is a systematic procedure of data analysis in order to identify the results, effects or impacts of programs and projects, as well as assess the efficiency and effectiveness of these against their goals. The multi-criteria analysis as a tool for decision support is applied to the comparative analysis of alternative projects. Through this technique several criteria can be taken into account, in the analysis of a complex situation (European Commission, 2013a). According Reichert (2012) there are two currents of thought: the American school - *Multi-criteria Decision Making* (MCDM) and the European school – *Multi-Criteria Decision Analysis* (MCDA).

4. Methodological Proposal

This section includes the proposed assessment methodology to the case study, belonging to the multi-criteria analysis (MCDA) through the MACBETH methodology. The MCDA methods are used to support complex decisions. Cinelli et al. (2014) classify the MCDA in three different families: multi-attribute utility theory / multi-attribute value theory (MAUT/MAVT), prevalence methods (outranking) and set of decision rules.

The MACBETH requires the decision-maker qualitative judgments about differences in attractiveness between performances on each criterion to propose a value scale compatible with these judgments, which is obtained by

linear programming, and requires judgments about differences in attractiveness between fictional alternatives, previously defined on the basis in reference performance levels (e.g. , the lowest level and the highest level of performance) to once more, by linear programming suggest weights for the evaluation criteria (Bana e Costa & Vansnick, 1999). While interactive multi-criteria approach it builds a quantitative evaluation model based on qualitative judgments, proving to be effective to avoid the "common" mistakes in scoring and weighting committed in several real cases reported in the literature. In the end this socio-technical method will allow to elaborate recommendations to prioritize and select the individual or group options through an additive value model (Bana e Costa & Vansnick, 1999; Bana e Costa et al., 2008b). This methodology uses a software package named M-MACBETH (Bana and Costa & Vansnick, 1999) that uses mathematical programming to obtain value and weighting scales. According to Bana and Costa et al., (2008b) three phases are identified to the construction of a MACBETH multi-criteria model:

- Structuring;
- Construction;
- Application.

The phase of **structuring** a multi-criteria model can follow two strategies: a strategy focused on alternative (alternative-focused thinking) or a strategy focused on the values (value -focused thinking). The main goal of the first is to identify the problem and alternatives and then discuss the values associated with these alternatives, however, this strategy restricts the discussion to alternatives. The other strategy (value-focused thinking) is more creative looking first at what adds value to the primary goal and then evaluates alternatives (Keeney, 1996). The strategy adopted was focused on values (value -focused thinking).

The **construction** of the methodological model is based on the additive value model, which allows to obtain an overall value score for each alternative as is described below Bana e Costa et al., 2008b).

The criteria are defined as C_j, j=1, …, n and its performance descriptors A_j, j=1…., n;

$V(a) = \sum_{j=1}^{n} k_j v_j(a)$ where $\sum_{j}^{n} k_j = 1$ and $k_j > 1$ and $\begin{cases} v_j(a^+) = 100 \\ v_j(a^0) = 0 \end{cases}$

Where:

$V(a)$ represents the overall value of alternative a;

$v_j(a)$ represents the partial value of alternative a on criterion j;

k_j represents the weight assigned to criterion j;

a^+ and a^0 are respectively the levels "Good" and "Neutral" assigned to each performance descriptor Aj.

The last stage of multi-criteria model consists on the definition of the intervention alternatives, implementation of the respective model, consistency and feasibility analysis of the model regarding the validation target problem and alternative selection of best value. The several stages of the methodological model are presented in Figure 4.

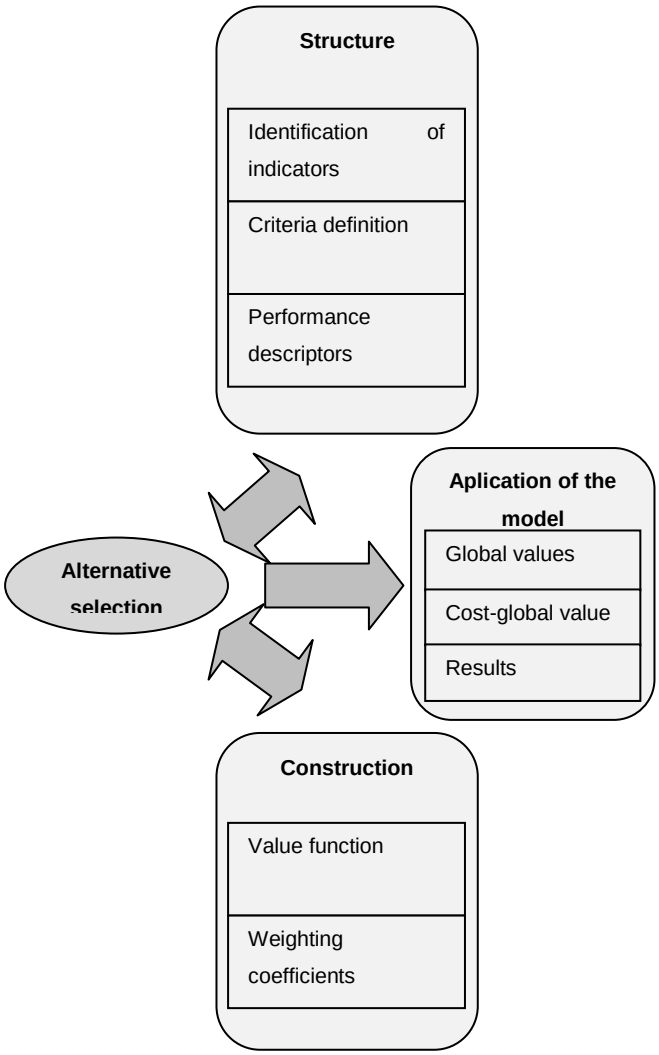

Figure 4 - Methodological model

5. Implementation

The implementation of the model was based on a socio-technical process using the M-MACBETH software and it was necessary to define the role of each stakeholder. There were two entities involved (UNICER and IST) that met in person twice.

5.1. Alternative selection

In the selection of intervention alternatives it was fundamental to make a first selection of those to be introduced later in the evaluation model. The selected alternatives were: **night deliveries, center of urban distribution and alternative vehicles.** The authors Kleinmuntz and Kleinmuntz (1999) support this decision suggesting that under the decision analysis, the decision-makers should focus on the proposals for greater impact preventing the process of evaluation of an overload by the proposed minor impact. Note that the set of alternatives to be evaluated includes the alternatives separately and together, generating seven different options.

5.2. Structure of the model

In the structure of the model, three major points of view were identified taking into account the UNICER goals: customer satisfaction, operational and investment costs. The evaluation of customer satisfaction was shared in five impact areas: delivery level, complaints, discharge duration, journey times and hourly window. For the evaluation of operational costs were considered the following areas: operation, occupancy rates and rerouting. Investment costs were taken into account in the last stage of the model with the achievement of a cost-multicriteria benefit graph. Figure 5 presents the M-MACBETH value tree

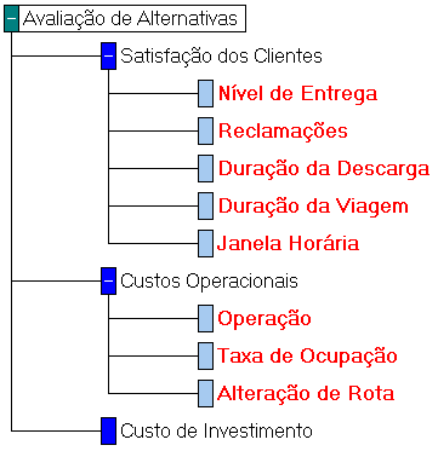

Figure 5 - Value tree

The next step was the operationalization of the above defined criteria through the assignment of a descriptor of performance to each one of them. Table 2 presents the,synthesis of the work accomplished with UNICER.

Table 2 - Criteria, descriptors of performance and reference levels

Criterion	Performance descriptor	Reference level
Delivery level	Ratio between the number of invoices delivered on the number of invoices [%]	Good=97
		Neutral=96
Complaints	Number of complaints received by the agent in one month. Unit [no.]	Good=1
		Neutral=3
Discharge duration	Daily average of the discharge time [min]	Good=8
		Neutral=14
Journey duration	Average duration of a journey between the distribution point until the supply point [min]	Good=30
		Neutral=50
Time window	Number of hours available to the goods supply [hr]	Good=6
		Neutral=3
Operation	Operation cost by tonne delivered. [€/Ton]	Good=45
		Neutral=51,5
Occupation rate	Ratio between the freight transported on the useful freight [%]	Good=92
		Neutral=80
Change of route	Number of actual kms travelled on the number of kms estimated [%]	Good=8
		Neutral=15

5.3. Construction of the model

After structuring the model, the next step was the construction of value functions capable to convert performances in values in each of the criteria. With the use of the existing MACBETH semantic scale: “null”, “very low”, “low”, “moderate”, “strong”, “very strong” and “extreme” the preference differences on each criterion were expressed between each two levels of performance.

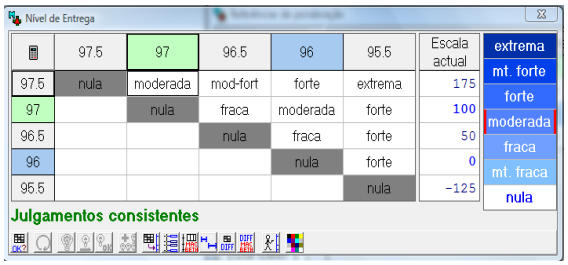

Figure 6 – MACBETH judgement matrix

To obtain the above judgements matrix in Figure 6 the following procedure was followed:

- The decision-maker was questioned about the preference difference between having a delivery level of 97.5% and 95.5%, to which the decision-maker answered by classifying it of “extreme”. The answers to this type of questions were used to fill in the judgements matrix on the criterion “delivery level”.

This procedure was repeated for all the criteria identified above (claims, the discharge duration, the journey duration, time window, operation, occupation rate and change of route). Then the value functions were generated by M-MACBETH and validated by the decision-maker (Figure 7).

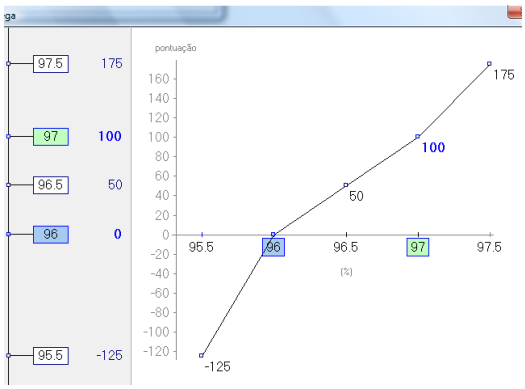

Figure 7 - Value Function , criteria "Nível de Entrega"

In the weighting procedure the decision-maker was asked to order the criteria by decreasing neutral-to-good preference. The criterion with the most important neutral-to-good improvement (operation) was placed in first

column in M-MACBETH, having repeated the procedure for the remaining criteria (column to the left in Figure 8). After ranking the criteria was necessary to fill in the matrix with new value judgments expressed by the decision-maker. The decision-maker was asked about the preference difference in changing from the neutral level to the good level in the first criterion ("operation") and successively until getting to the last criterion ("discharge duration"). In the first criterion this preference difference was classified between "very strong to extreme" (see Figure 8.)

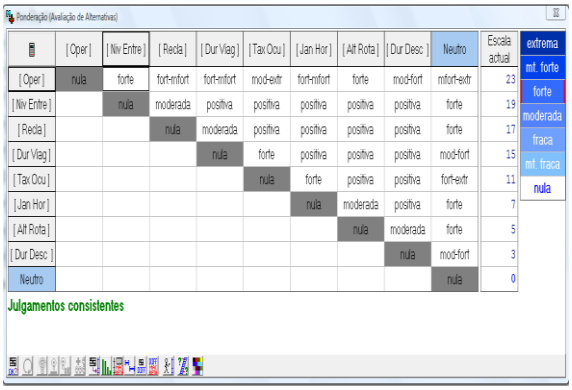

Figure 8 - Judgement matrix to weighthing coefficients

The remaining judgements were obtained questioning the preference difference between the neutral-to-good gains in two different criteria. In Figure 9 the decision-maker was asked about the preference difference between two improvements (neutral-to-good in the "operation" and "delivery level" criteria. The answer to that question was "strong" and can be observed in figure 8.

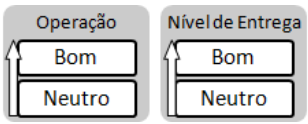

Figure 9 - Gains between two criteria

The procedure was executed until the total fulfillment of the judgements matrix. After that M-MACBETH proposed the weighting coefficients shown in Figure 10.

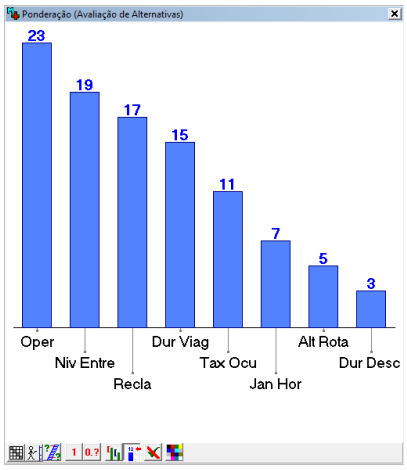

Figure 10 - Weighthing coefficients

5.4. Application

The application of the model took into account the performance of the different intervention alternatives in each criterion. The set of alternatives to be evaluated can be observed in Figure 11.

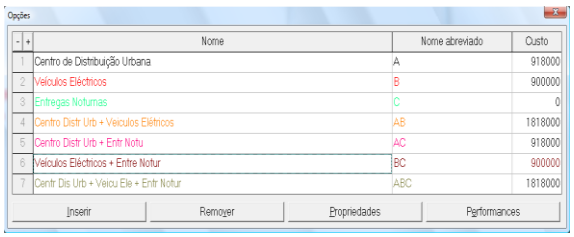

Figure 11 - Evaluated alternatives

The performances of the alternatives were then inputed in M-MACBETH (see Figure 12).

Opções	Niv Entre	Recla	Dur Desc	Dur Viag	Jan Hor	Oper	Tax Ocu	Alt Rota
A	99	2	11	10	3	45	92	4.5
B	99	2	11	40	6	54.75	92	8
C	96	3	8	40	9	60	92	6
AB	99	2	8	10	6	70	92	2
AC	96	3	8	8	9	60	92	6
BC	96	3	8	30	9	80	92	6
ABC	96	3	8	8	9	100	92	2

Figure 12 – Performances of the alternatives

This way each intervention alternative obtained a score in each criterion that, through the additive value model, was converted in a global performance value (Figure 13).

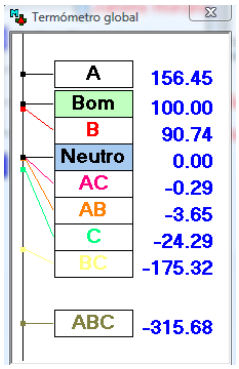

Figure 13 - Alternatives ranking

Alternative A, which represents the implementation of a **center of urban distribution,** obtained an overall score of 156.45 value units, placing itself above the "good" reference level. A cost-muticriteria benefit analysis was also performed. In the process of estimating the costs associated to the seven intervention alternatives involved, the following assumptions have been made (see Table 3).

Table 3 - Investment costs (INE, 1935; Associação Portuguesa do Veículo Elétrico, 1999)

Intervention alternative	Unit cost	Total cost
Center of urban distribution	1836 €/m^2	500x1,836 = €918,000
Electrical vehicles	€75,000	75,000x12 = €900,000
Night deliveries	€0	€0

In Figure 14 a XY graph was created by M-MACBETH, with the investment costs and overall value scores of the alternatives. Alternatives A, B and C are efficien.. Analysing alternatives A and B and taking into account their cost difference (€918,000 – €900,000) and the score increase between them (156 – 90) the decision-maker considered worthy paying more to obtain the additional overall multicriteria value provided by alternative A (66 value units). The principal output is the recommendation of selection of alternative A (center of urban distribution) for is the best intervention alternative according to the evaluation criteria defined by the economical agent.

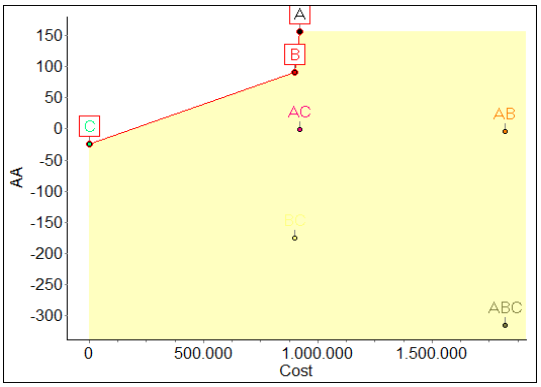

Figure 14 – Investment Cost-global value

5.5. Recommendations

In this section a few recommendations are illustrated resulting from the implementation of the model built to the present study case. According the decision-maker, there is in downtown Lisbon an appropriate local for a center of urban distribution, Jardim do Tabaco. The same decision maker revealed an excessive concern for costs and the Portuguese labor law fruit of its low flexibility. A recommendation made by the economical agent is to search for more micro solutions, not so macro in order to improve the distribution, illustrating with a possible effort to strengthen partnerships between retailers, economical agents and population in order to consolidate the trust among them.

6. Discussion and Conclusion

The developed work proves to be a good exploratory start that in the future can lead to further work based on a multi-stakeholder approach. With this, it means that the recommendations in this work can be complemented with more judgments from other stakeholders, being this model a good basis to other work that are interesting to accomplish. The approach defended in this document is

from only one stakeholder, however, a multi-stakeholder approach would be richer, bringing more perspectives to the evaluation. The methodological model proved to be simple and appropriate to the case study. The results based on the survey of problems affecting the beverage distribution downtown Lisbon, resulted in well-defined criteria, attractive alternatives to the economical agent and were highlighted the lack of universal solutions to this kind of problems. The performances of the alternatives were based on the best estimates of the decision-maker, which are recognized as uncertain.

The alternative with the best overall value score is the center of urban distribution with 156 points, in a scale where 100 points and 0 points represent a good performance in all the criteria and a neutral performance, respectively. The MACBETH methodology has been extensively used in this kind of problems and proves to be an useful tool in assisting decision-makers to select alternatives with different performances.

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