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Decision Making on the choice of Companies to be settled in cities using multi-criteria method (AHP) as Public Management Support. A Case Study.

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Abstract. The objective of this study is to present a method to help decision makers in the choice of installation of companies in cities, using the multicriteria Analytic Hierarchy Process (AHP) method. As a methodological approach, a review of literature and a field research was conducted to develop a model to be employed in a case study. The result demonstrates the importance of attracting metal mechanic industries and consumer goods to the studied city. The method presented in this study is a valuable tool that public managers can use to make a good decision making to minimize the risk of biased influences in the decision-making process and thereby maximizing the progress of cities in a sustainable way.

Keywords urban planning & AHP; smart cities opportunity for entrepreneurship; smart city & AHP; smart cities & urban planning

1 Introduction

Urban Planning and Territorial Management are currently one of the main focuses of a social and political organization, for their influence on life quality and for the impact on socioeconomic development. In this context, considering the growing challenges imposed by a globalized world and an increasingly competitive country (Brazil), managers trend to assume and interpret, from a multidisciplinary perspective, factors related to territorial administration and, consequently, their sustainability and competitiveness. Chuang (2001) identifies as important quantitative criteria for the location of companies, land and real estate costs, in and out transportation costs, quantity of supplies, proximity to consumers and retailers, availability of technical manpower and, as qualitative criteria, environmental factors, life quality and government policies. The ability to become attractive to foreign investments and motivations to internal growth, make public management one of the great challenges nowadays. From several perspectives, they look for models that foment development, the life quality improvement in the cities and, simultaneously, fundraising increase, to be reverted in the promotion of the cities´ own development and progress. It is usual to find studies that look for mathematical methods as an option to choose how to install a new factory, or even a subsidiary, among different options of existing cities, using different parameters. Such studies demonstrate the companies´ standpoint, promoting the best city´s choice, resulting by this in a stagnation on their expectative of receiving any type of company that comes to settle in the cities; however, by now there are no studies that focus in the cities' aspirations and seek, according to their vocations, for an isonomic choice of the best types of companies that meets the urban planning of cities. The lower cost or greater tax incentive should not be the only measure when choosing the location of a company; other factors must be considered at this time, at risk of major financial losses and frustration by entrepreneurs and public management. None of the previous work studies, as described in the literature review, dealt with the development of a method for prioritizing factors as a means to allow effective decision making. The literature research revealed that most of the previous studies did not address the need to focus on cities' aspirations and their vocations. The paper provides answers to the following research questions: 1 - How to select suitable companies for a city in order to meet the criteria of its Urban Planning and, at the same

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time, the expectations of these ventures with the AHP methodology? 2 - Applying the proposed methodology in a case study in Petropolis, City from Rio de Janeiro, what is the ideal company profile to be settled there, considering criteria such as vocations defined by the city administration?

2 Objectives

This. Justified by the importance of decision-making about location of companies in cities, and the lack of a method to assist it, this study aims to present a multicriteria method to find, within the scope of public management, a better definition for the installation of companies in cities, using the multicriteria Analytic Hierarchy Process (AHP) method. It presents an analysis of relevant factors that helps Public Management to choose which types of companies are best suited to a particular city, in order to meet the criteria of Urban Planning of this city, its vocations and, at the same time, the enterprises´ expectations. The study model had as development motivation the expansion of a city and its necessity to attract companies that come to establish themselves in the city, due to common interests and natural attractions

3 Methods

The case study was conducted by analysing and reviewing previous work on Urban Planning, by conducting a survey, based on information obtained from previous literature and in interviews with experts from the field. For (Hartley, 2004), the case study is not a method, but a research strategy, which may employ qualitative methods, quantitative methods or both. To identify the factors that influence the decision-making process of what companies and which types of them are best suited to a particular city and, concomitantly, how it should prepare itself to become or remain attractive to new entrepreneurs, a research with theoretical and scientific basis for the study was necessary. Part of the methodological research process linked to this study is based on the sequential steps of decision-taking, using the AHP. Document data collection, field research and case study were performed, as described in Figure 4

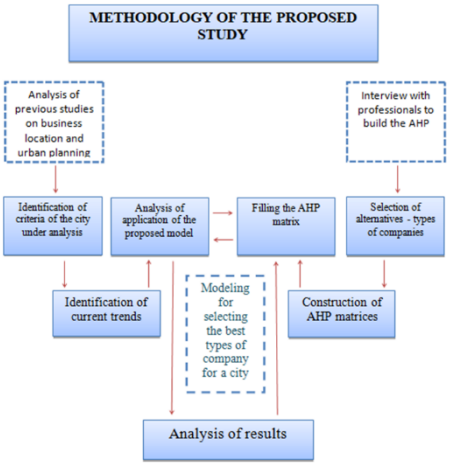

Figure 1. Methodology

This study is a blend of qualitative and quantitative research, which facilitated the understanding of the relevant factors that helps public management to choose which types of companies are best suited to a particular city. It consisted of literature research, analysis of records and opinion from different experts and professionals in urban planning. This ensured that the analysis was not explored through the expertise and experience of professionals from one specific place only, but rather from different ones, which allowed for understanding of the multiple facets of relevant factors. The urban planning process was well explored, and the essence of factors existing in the different steps was revealed. The approach used in this study was a Single Case type with Embedded Units (Baxter, P., & Jack, 2008). It looked at the urban planning process, but from different perspectives of experts working in different places. This holistic case study with embedded sites enabled the exploration of the urban planning process, while considering the influence of

the various sites and associated experiences of experts on urban planning process in different places. The engagement in this analysis only served to better assess the factors present in the urban planning process and understand the global factors involved. This case study type is classified as intrinsic (Stake, 1995), since there was a genuine interest in better understanding the relevant factors present in urban planning process that could best suit a particular city. The literature research and the personal experiences of experts allowed the identification of these factors. The interviewed experts were strategically selected, so that all different processes steps in the urban planning process were covered considering a holistic approach. A focused analysis was performed aiming at answering the research questions and ensuring the data converged to understand the relevant factors in the urban planning process. The process was viewed and explored from multiple perspectives and the collection and comparison of this data enhanced data quality. A prolonged and intense exposure to the process and its context was necessary so that multiple perspectives could be collected and understood. The mapped-out process and the factors were shared with the experts from the different places, who had the opportunity to discuss, clarify the interpretation of factors and contribute with new or additional perspectives on the factors. Data from these multiple places was then converged in the analysis process. Each piece of data source contributed to the understanding of the whole process. This convergence added strength to the findings as the various strands of data were braided together to promote a greater understanding of the case. The data collection and analysis occurred concurrently. The collected data was analysed and prioritized by using AHP. It is an excellent tool to provide weight for the different risk levels, the first phase is to create a pairwise evaluation matrix (A), as introduced by (Saaty, 1980), by utilizing the relative importance scale shown in Table 1. Multicriteria decision-making methods have emerged as support ways that are seen as effective mathematical tools for solving problems in which conflicting criteria exist (Brans and Mareschal, 2005). Such methods provide the user classification and "ranking" of the candidate places (Saaty; Vargas, 2012).

Table 1. Relative Importance Scale

Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Absolute Extreme Importance
2, 4, 6, 8	Intermediate values

The matrix *A* represents a pairwise evaluation matrix where each element a_{ij} (i, j = 1, 2, ..., n) represents the proportional importance of two compared elements (i and j). The higher its value, the stronger the preference of first element (i) over the second (j). (Mls and Otcenaskova, 2013). The matrix is shown in equation (3).

$$A=\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix},\ a_{ii}=1,\ a_{ji}=\frac{1}{a_{ij}},\ a_{ij}\neq 0 \tag{3}$$

Subsequently, the priority weights of each criterion are established with the next equation:

$$w_i=\frac{1}{n}\left(\sum_{j=1}^{n} a_{ij}\right)\Bigg/\left(\sum_{k=1}^{n} a_{kj}\right) \tag{4}$$

The succeeding step in the AHP method is to demonstrate reliability of data (Saaty, 1986). suggested a basic equation to check if the evaluation pairwise matrix is reliable. The consistency index (CI) is calculated as follows:

$$CI=\left(\lambda_{\max}-n\right)/\left(n-1\right) \tag{5}$$

Where n is the order of the matrix A and λ_{max} is its dominant Eigenvector, which satisfies the following equation:

$$\sum_{j=1}^{n} a_{ij} w_j = \lambda_{\max} w_i \quad (6)$$

A consistency ratio (CR) estimation is then needed to verify the sensible consistency. The CR value can be estimated by equation (7). The CR value needs to be equal or smaller than 0.10 if not the expert elicitation needs be revised to get a reliable result. In the equation, CRI represents the random consistency index (RCI), presented by (Saaty, 1994).

$$CR = CI / RCI \quad (7)$$

The RCI assessment table is obtained from Table 2, propose by (Dong and Saaty, 2014).

Table 2. Random Consistency Index

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

4 Results

The Vocations at Figure 2, presented in the city`s Plurennial Planning for the current management (2016-2020), fit perfectly into Criteria that the AHP method needs to assemble the Hierarchy Decision.

Figure 2. Vocations

All companies (Alternatives) are compared to each criterion (Vocations), and each criterion was compared to the final objective, which is to select the ideal company for Petropolis, as shown at Figure 3.

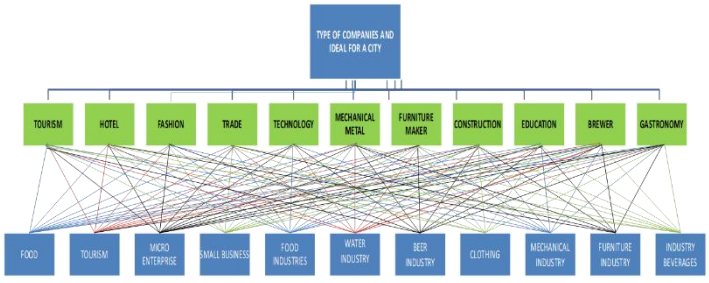

Figure 3. Alternatives and Criterion

From the structuring of the Criteria hierarchy at figure 4, applied the Vocation evaluation questionnaire described at figure 2, a parity comparison matrix of Criteria was created by the author (Vocations) using "Excel software". By this, all criteria were judged and compared among themselves, as shown in the Criteria Comparison Matrix (Vocations), at Figure 4.

MATRIX COMPARISON OF CRITERIA

VOCATIONS	TOURISM	HOTEL	FASHION	TECHNOLOGY	MECHANICAL METAL	FURNITURE MAKER	CONSTRUCTION	EDUCATION	TRADE	BREWER	GASTRONOMY	NORMALIZE MATRIX										WEIGHTING
TOURISM	1	5	7	3	3	7	7	3	5	3	3	0,29	0,14	0,23	0,40	0,20	0,19	0,30	0,44	0,13	0,30	0,11	0,25
HOTEL	1/5	1	1/3	1/7	1/5	1/3	1/3	1/7	1	1/5	1	0,06	0,03	0,01	0,02	0,01	0,01	0,01	0,02	0,03	0,02	0,04	0,02
FASHION	1/7	3	1	1/9	1/7	1	1/3	1/5	1	1/3	1	0,04	0,08	0,03	0,01	0,01	0,03	0,01	0,03	0,03	0,03	0,04	0,03
TECHNOLOGY	1/3	3	5	1	3	5	3	1	7	1	5	0,10	0,08	0,16	0,13	0,20	0,14	0,13	0,15	0,18	0,10	0,18	0,14
MECHANICAL METAL	1/3	5	3	1/3	1	3	3	1/3	3	1/3	3	0,10	0,14	0,10	0,04	0,07	0,08	0,13	0,05	0,08	0,03	0,11	0,08
FURNITURE MAKER	1/7	3	1	1/5	1/3	1	1/3	1/5	1/3	1/5	1/3	0,04	0,08	0,03	0,03	0,02	0,03	0,01	0,03	0,01	0,02	0,01	0,03
CONSTRUCTION	1/7	3	3	1/3	1/3	3	1	1/5	5	1/3	5	0,04	0,08	0,10	0,04	0,02	0,08	0,04	0,03	0,13	0,03	0,18	0,07
EDUCATION	1/3	7	5	1	3	5	5	1	7	3	5	0,10	0,19	0,16	0,13	0,20	0,14	0,21	0,15	0,18	0,30	0,18	0,18
TRADE	1/5	1	1	1/7	1/3	3	1/5	1/7	1	1/5	1/3	0,06	0,03	0,03	0,02	0,02	0,08	0,01	0,02	0,03	0,02	0,01	0,03
BREWER	1/3	5	3	1	3	5	3	1/3	5	1	3	0,10	0,14	0,10	0,13	0,20	0,14	0,13	0,05	0,13	0,10	0,11	0,12
GASTRONOMY	1/3	1	1	1/5	1/3	3	1/5	1/5	3	1/3	1	0,10	0,03	0,03	0,03	0,02	0,08	0,01	0,03	0,08	0,03	0,04	0,04
TOTAL	3,50	37,00	30,33	7,46	14,68	36,33	23,40	6,75	38,33	9,93	27,67												

Figure 4. Vocations

At Figure 5, the "TOURISM" criterion was the one that received the highest average score (0.25), when compared to the final objective of selecting suitable companies for a city in order to meet the Urban Planning criteria. It is also observed that, the "EDUCATION" criterion was the second most important option, punctuating 0.18, followed by the "TECHNOLOGY" criterion. Among the Vocations, according to the judges, the lowest score are "Fashion", "Furniture" and "Trade", which tie with 0.03 of average. From this point on, we get the Matrix Normalized, and the Normalized Auto Vector, which is extremely important for the final conclusion and precise decision. Thus, 11 spreadsheets were developed, one for each vocation (Criteria). The Figure 5 illustration represents the worksheets of the first vocations analysed by the leaders (judges) from the Economic Development Department of the studied city, which is Tourism. Then, 11 spreadsheets, one for each vocation, were evaluated in the same way so the relevant trends and associations could be evaluated for each vocation

MATRIX COMPARISON OF ALTERNATIVES

TOURISM	FOOD	TOURISM	MICRO ENTERPRISE	SMALL BUSINESS	FOOD INDUSTRIES	WATER INDUSTRY	BEER INDUSTRY	CLOTHING	MECHANICAL INDUSTRY	FURNITURE INDUSTRY	INDUSTRY BEVERAGES	NORMALIZE MATRIX										NORMAL VECTOR
FOOD	1	1/3	5	3	1/7	1/7	1/5	1/5	1/9	1/3	1/9	0,02	0,09	0,10	0,09	0,00	0,01	0,03	0,01	0,00	0,02	0,01	0,04
TOURISM	3	1	3	5	7	5	3	5	3	5	3	0,06	0,28	0,06	0,15	0,17	0,21	0,50	0,37	0,10	0,31	0,26	0,22
MICRO ENTERPRISE	1/5	1/3	1	1/3	1/5	1/5	1/7	1/7	1/5	1/3	1/7	0,00	0,09	0,02	0,01	0,00	0,01	0,02	0,01	0,01	0,02	0,01	0,02
SMALL BUSINESS	1/3	1/5	3	1	3	1/3	1/5	1/7	3	1/3	1/5	0,01	0,06	0,06	0,03	0,07	0,01	0,03	0,01	0,10	0,02	0,02	0,04
FOOD INDUSTRIES	7	1/7	5	1/3	1	1/3	1/7	1/7	1	1/5	1/7	0,14	0,04	0,10	0,01	0,02	0,01	0,02	0,01	0,03	0,01	0,01	0,04
WATER INDUSTRY	7	1/5	5	3	3	1	1/3	1/5	3	1/3	1/5	0,14	0,06	0,10	0,09	0,07	0,04	0,06	0,01	0,10	0,02	0,02	0,06
BEER INDUSTRY	5	1/3	7	5	7	3	1	3	7	5	3	0,10	0,09	0,14	0,15	0,17	0,13	0,17	0,22	0,22	0,31	0,26	0,18
CLOTHING	5	1/5	7	7	7	5	1/3	1	5	3	1/3	0,10	0,06	0,14	0,21	0,17	0,21	0,06	0,07	0,16	0,19	0,03	0,13
MECHANICAL INDUSTRY	9	1/3	5	1/3	1	1/3	1/7	1/5	1	1/5	1/3	0,18	0,09	0,10	0,01	0,02	0,01	0,02	0,01	0,03	0,01	0,03	0,05
FURNITURE INDUSTRY	3	1/5	3	3	5	3	1/5	1/3	5	1	3	0,06	0,06	0,06	0,09	0,12	0,13	0,03	0,02	0,16	0,06	0,26	0,10
INDUSTRY BEVERAGES	9	1/3	7	5	7	5	1/3	3	3	1/3	1	0,18	0,09	0,14	0,15	0,17	0,21	0,06	0,22	0,10	0,02	0,09	0,13
TOTAL	49,53	3,61	51,00	33,00	41,34	23,34	6,03	13,36	31,31	16,07	11,46												

Figure 5. Vocation Tourism

5 Conclusion

Returning to the research objective, it is important to emphasize that the main contribution of the study is to demonstrate a multi-criteria method that allows better parameters to settle companies in cities among urban management - Analytic Hierarchy Process (AHP). It also assists the public manager in entrepreneurship development as well as attracts entrepreneurs who wish to settle in a certain city that can meet their expectations and strategic planning. It evaluates and identifies the importance of the Vocations that the whole city has using them as a guide to public strategies. In response to the first question of this research, it was verified that the AHP method used to choose types of companies under a certain criterion, lived up to the expectation, as three types of companies were detected, better aligned for the development of the city studied. Regarding the second research question, the case study of Petropolis city, it revealed three types of companies. Considering the strategic profile of the current administration and the City`s Vocations, it shows that the first choice of company type is the Metal Mechanics Industrial area, which better meets the aspirations of this city studied, indicating the need for more jobs and demonstrating to be closely linked to the "Work and Income" issue in the city. The research aimed to present the AHP method construction as a way to build and adapt the criteria to the cities` vocations and to bring the types of companies as alternatives for the method application. It also presented questionnaires that could be used to facilitate peer evaluation that participants should perform to achieve the objective. It could be observed that the method was able to reach the final objective of ranking and classifying the most appropriate types of companies to be attracted to a particular city, providing basis for Managers and Entrepreneurs to make isonomic and assertive decisions, without considering private interests, minimizing the risks of biased influences in the decision-making process. In addition to maximizing the cities` progress in a sustainable way, this methodology can guide Management Plans into appropriate decisions and, therefore, the well-being of society over individual objectives. The model developed in this study can serve as a proposal for other cities that need to attract and even decide what types of companies are most appropriate to the municipality. It also leaves as a contribution the use of criteria applied in the APH methodology as Cities` Vocations, Alternatives´ vocations like types of companies in modelling that can be used as reference for other studies, managers and cities. This study aims the identification and hierarchical analysis of the best types of companies to be settled in cities; however, it does not take into account or is not foreseen in the decision making of this modelling, the types and quantities of companies already installed in the city. This issue as well as the search for an “Ideal Mix” of interdependent companies and, at the same time, complementary companies, may be proposed for future research. It is also possible to merge the AHP method with other decision-making methods and statistics that may improve the results already obtained and, at the same time, may achieve greater assertiveness in new challenges. As proposed in the introduction, the study provided responses to the two research questions. AHP proved to be an effective method to assess and prioritize the critical factors. The in-depth analysis of current literature about the subject and the opinion of experienced individuals allowed the identification of critical factors in urban planning. This study is very important, because understanding the critical factors can influence the decision-making process.

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