From decision making without complexes

It is important to note that a basic condition for a decision problem to exist is that there must be at least two alternatives for the decision maker to make his choice[1]. When there is a finite number of alternatives (discrete condition [2]), the following types of problems are encountered: of selection, sorting, classification and description. Whereas if the number is infinite (continuous condition), the problem is an optimization problem[3]. In order to make a good decision, mathematical models or knowledge of psychology must be rationally incorporated, even a combination of both[4].

A Multicriteria Decision[5] is the set of approaches, methods, models, techniques and tools aimed at improving the overall quality of the decision processes followed by individuals and systems. There is a branch of Operations Research [6] that explicitly evaluates multiple criteria, which is Multiple Criteria Decision Making (MCDM) or multi-criteria decision-making, which helps to make decisions on a complex problem by evaluating and choosing alternatives to solve it using different criteria and points of view.

In general, the procedure [7] follows six steps that include (1) formulating the problem, (2) identifying requirements, (3) establishing objectives, (4) identifying various alternatives, (5) developing criteria, and (6) identifying and applying the decision-making technique. To facilitate systematic research in the field of MCDM, Hwang and Yoon (1981) [8] suggested that MCDM problems can be classified into two main categories: multiple attribute decision making (MADM) and multiple objective decision-making (MODM), based on different purposes and types of data.

Among the MADM groups, the pairwise comparison methods stand out, including the Analytic Hierarchy Process (AHP) introduced by Thomas Saaty in the 1970s and then the Analytic Network Process (ANP) in 1996. Among his co-authors and colleagues are Ernest Forman and Luis Vargas. *Saaty*[9] is one of the most successful people in the field of information management and communications in the dissemination of his method for complex decision-making. In a research conducted by Ishizaka&Nemery (2013) [10] the classification of problems with their solutions based on MADM methods was made. AHP and ANP are associated to the solutions of selection and classification problems.

At the end of the year 2021, the author of this article did a research on the State of the Art of the application of the Analytic Hierarchy Process (AHP) in asset valuation. The main objective was to analyze the methodology proposed at the beginning of the 21st century, based on the use of AHP for the valuation of urban real estate. After processing the information and with an empirical basis, the following videos were produced: 1) From the encounter between a model, a ratio and a process[11]; 2) Valuation ratio + control metrics [12] ; and 3) Valuation ratio under probabilistic scenarios [13]. It was shown that the results of the general weighting vector (Ranking) provided by the application of the AHP are not binding for the valuation of real estate, that is, the use of the Valuation Ratio does not guarantee reciprocity for the estimation of market values.

In the year 2022, as a continuation of the research line on the use of AHP for the solution of problems in the selection of products in the real estate market. The engineer Miguel Camacaro, as main author, produced it and the architect Ernesto Mock, as collaborator, the work entitled «An econometric model MLRM + Analytical Hierarchical Process (AHP) to select the best alternative for a real estate investment. Case: Apartment in Panama City (Panama)».[14]

The paper was approved for online presentation in October/2022 at the 21st International Conference of the Latin American Real Estate Society (LARES)[15], São Paulo-Brazil; and in December of that same year, at the International Symposium on the Analytic Hierarchy Process (ISAHP 2022)[16] Pittsburgh-USA. This is a case study for the selection of an apartment located in a sector of Panama City (Panama), for which 97 offers with a price range between [165,000 and 215,000]USD were analyzed. The variables from the Multiple Linear Regression Model (MLRM), which were statistically significant in explaining total real estate prices, and considered in the multicriteria method, were as follows: area, parking space, age, quality, building floor and distance to the value-adding pole. The entire procedure established for applying the AHP was followed, but the Saaty Table was not used to structure the pairwise comparison matrix for the criteria. In order to determine the eigenvector of the criteria, the importance of the intensity in the fundamental scale was replaced by the ratio between the standardized coefficients (t^*) of each

explanatory variable of the econometric model. The following table shows the results of the vector of general weightings for the ranking of the alternatives:

	Saaty's Table	Statistical (t*)
PH Arenas Park	0,24	0,26
PH Vista Marina Tower	0,16	0,19
PH Coral Tower	0,32	0,28
PH Miradores Residences	0,28	0,27
Mean	0,25	0,25
Standard deviation	0,07	0,04
Coefficient of variation (C.V.)	28%	17%

It is observed that the order of the alternatives coincide, and the first place corresponds to the property located in PH Coral Tower. But there is greater variation between the values of the alternatives in the overall weighting vector when using the Saaty Table (C.V. 28%) compared to when using the t* statistics (C.V. equal to 17%), more robust results than the heuristic solution provided by the original AHP procedure. Among the important points for the proposed replacement of the Saaty table values are:

- Not conducting surveys among experts and stakeholders, mitigating subjectivity when comparisons are made.
- The use of the ratio between the t* coefficients of the variables of the regression model guarantees the consistency of the criteria matrix, by virtue of the proportionality of the ratios the λmax is equal to the number of elements of the matrix (n), therefore, the consistency index (CI) is zero and consequently the Consistency Ratio (CR) will be zero.
- The use of quantitative variables for the criteria makes it possible to normalize the variables directly and thus more easily obtain the eigenvector of the alternatives without using the pairwise comparison matrices of experts and stakeholders.
- There is no limitation on the use of a certain number of variables to obtain the ranking and subsequent decision-making, as long as they are statistically significant variables verified by the MLRM.

As for the discussion of the proposed content of the work, the following is presented:

- When MADMs are used with an empirical foundation, decision makers (DMs) are very likely to optimize the selection of the best alternative for their investment, business or company. However, the solution provided by a multi-criteria method alone does not necessarily represent the ultimate decision.
- The econometric model must be correctly specified, including the important variables to explain the price of the real estate market.
- Since the emergence of the popular multi-criteria AHP method, the fundamental scale of the Saaty Table has been widely investigated, with mixed opinions in the scientific community.
- The suggested methodology for the substitution of the pairwise comparison in the criteria and alternatives matrices by numerical matrices based on relationships between MRLM test statistics and the use of quantitative variables requires that the real estate consultant has full knowledge of the behavior of real estate prices and the variables involved in their formation.
- The figure of the real estate appraiser is key to analyze the databases, and with the use of scientific methodology generate the econometric models to extract the test statistics that empirically support the solutions when using AHP.
- At present, there are several computer programs, such as Super Decisions[17], which facilitate access to mathematical calculations that allow consolidating the knowledge and development of the AHP multi-criteria method. There are also several technological tools that allow, in this era of Big Data and Data Science, the processing of data to provide solutions when it is necessary to make a decision using multiple criteria.

As to the conclusion of the research work:

- The use of the matrix of relationships between the t* statistics associated with the MRLM variables replaces expert judgments in surveys based on the Saaty Table, allowing decisions to be made with a sufficient degree of objectivity.
- For the analysis of real estate offers, the t* Criterion represents a valid alternative and supports the work of real estate professionals, with the advice of expert appraisers, when using the AHP to optimize the marketing of real estate products and satisfy the requirements of potential buyers for the best investment decision.

To continue with the line of research, the Analytic Network Process (ANP) will be used in the following work, that is, with the results obtained with the AHP to incorporate other test statistics of the Multiple Linear Regression Model (MLRM) for

the different comparisons of the variables and alternatives (external and internal dependence) belonging to clusters, elements and links that make up the ANP network.

Miguel Camacaro Pérez, M.Sc.
mundovalor@gmail.com

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[9] According to the content of the Part of the history of Multiple Criteria Decision Making (MCDM) taken from the website of the International Society on Multiple Criteria Decision Making. https://www.mcdmsociety.org

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[11] Mundo Valor Channel (January 19, 2023). From the encounter between a model, a ratio and a process. [video file] Youtube: https://youtu.be/QPt217J_1As

[12] Mundo Valor Channel (January 19, 2023). Valuation ratio + control metrics. [video file] Youtube: https://youtu.be/50Kf64WAv9s

[13] Mundo Valor Channel (January 19, 2023). Valuation ratio under probabilistic scenarios. [video file] Youtube: https://youtu.be/KuWYcm8VUSw

[14] Mundo Valor Channel (January 19, 2023). An econometric model MLRM + Analytical Hierarchical Process (AHP). [video file] Youtube https://youtu.be/ECDUpnrXGos

[15] The Latin American Society of Real Estate Studies - LARES is an academic entity that extends to the market, and aims to promote the development of studies in different areas of knowledge, with professionals, academics and researchers who, through the association, participate in events and exchanges with related societies. LARES is affiliated to IRES - International Real Estate Society. http://lares.org.br/

[16] The International Symposium on the Analytic Hierarchy Analytic Process for Decision Making (ISAHP) brings together researchers, academics, students and other users of AHP/ANP to share their research and experiences in decision making. The ISAHP is a biennial conference on multi-criteria decision analysis, with a focus on the analytic hierarchy process (AHP) and its extension, the analytic network process (ANP). https://www.isahp.org/

[17] https://www.superdecisions.com/