VILNIUS TECH
Vilnius Gediminas Technical University

International Journal of Strategic Property Management
ISSN: 1648-715X / eISSN: 1648-9179
2022 Volume 26 Issue 4: 305–317
https://doi.org/10.3846/ijspm.2022.17922

A MULTICRITERIA EVALUATION SYSTEM FOR LARGE REAL ESTATE INVESTMENTS

Rita S. B. S. SOARES[1], Fernando A. F. FERREIRA[1,2,*], Fernando J. C. S. N. TEIXEIRA[3], Neuza C. M. Q. F. FERREIRA[4]

[1] *ISCTE Business School, BRU-IUL, University Institute of Lisbon, Avenida das Forças Armadas, 1649-026 Lisbon, Portugal*
[2] *Fogelman College of Business and Economics, University of Memphis, Memphis, TN 38152-3120, USA*
[3] *School of Technology and Management, Polytechnic Institute of Beja, Rua Pedro Soares, 7800-295 Beja, Portugal*
[4] *NECE-UBI, Research Center for Business Sciences, University of Beira Interior, Estrada do Sineiro, 6200-209 Covilhã, Portugal*

Received 06 September 2022; accepted 25 October 2022

Abstract. As an economic engine of contemporary societies, the real estate market needs to be carefully analyzed in terms of both urban management and private or public investment. Information on this market's behavior can facilitate the identification of turning points in societies' economic history. Analysts should focus not only on conditioning variables and other important determinants of relevance to investment evaluations but also on the impacts of each variable or factor. Measuring these effects is a key activity in decision-making processes. Given real estate's growing importance to sustainable economic growth, this study concentrates on creating a multicriteria model for evaluating large real estate investments. A constructivist, process-oriented approach was applied in group work sessions held with a panel of experts with experience in dealing with this issue. These specialists structured the problem of evaluating large real estate investments using value-focused thinking (VFT) and cognitive mapping. The best-worst method (BWM) was then applied to calculate trade-offs among decision criteria and calibrate the evaluation system. The results were presented to and validated by a representative of *Instituto da Habitação e da Reabilitação Urbana* (Institute for Housing and Urban Rehabilitation), who identified the advantages and limitations of the proposed model, and suggested possible improvements.

Keywords: best-worst method (BWM), cognitive mapping, large investment, measurement, real estate, sustainability, value-focused thinking (VFT).

Introduction

Companies today need to ensure they apply the best resource management practices to guarantee their sustainability. Organizations should thus increasingly focus on making adjustments to match customers' needs and aspirations based on sustainability assumptions (Mera & Renaud, 2000; Zhang, 2016; Pérez-Gladish et al., 2021). Managers' ability to discover clients' real needs and collaborate in decision-making processes is directly related to their commitment to making constant measurements and evaluations.

The real estate market is an integral part of the economic engine of contemporary societies, so this sector needs to be carefully studied in terms of both urban management (*i.e.*, at the municipal level) and private or public investment. The present study develops a multicriteria model that avoids a static approach and allows the relevant decision makers to monitor and review their management practices constantly. According to Bana e Costa et al. (1997, p. 37), *"to help people make decisions is, above all, to help them express judgments of value and learn about their preferences"*. The current research thus created a tool that facilitates reflective assessments of clients' needs and preferences based on an assessment model that facilitates decisions about which actions to take. Specifically, this study focused on developing a decision-support system that uses value-focused thinking (VFT) (Keeney, 1996) and the best-worst method (BWM) (Rezaei, 2015) to evaluate large real estate investments.

*Corresponding author. E-mails: *fernando.alberto.ferreira@iscte.pt*; *fernando.ferreira@memphis.edu*

The study relied on the direct participation and professional knowledge of a panel of decision makers to structure the decision problem under analysis (*i.e.*, evaluate large real estate investments). These specialists next identified the relevant variables and their respective weights in assessments of these investments and helped develop an appropriate decision support tool by providing their practical input. The tool's applicability was then evaluated and validated by an independent expert who was in a position to implement it in real-life contexts. The results offer added value in terms of investment analysis because of the constructivist techniques employed. This research thus sought to improve resource management and provide decision-making support via an analytical tool that facilitates more accurate evaluations of large real estate investments.

The remainder of this paper is structured as follows. The next section presents the literature review and the research gaps uncovered. The following section provides the methodological background and reasons for selecting specific methods and techniques. The results are then described and discussed. The final section offers the conclusions and guidelines for future research.

1. Related literature and research gaps

Real estate is not limited to housing construction. The importance of locating projects and planning the surrounding areas–including roads and generated flows–underlines that real estate products are intended to be profitable and sustainable in the long term (DiPasquale & Wheaton, 1992; Geltner et al., 1992; Archer et al., 1997; Ebrahim & Hussain, 2010; Ribeiro et al., 2017; Ferreira et al., 2022). These products have six fundamental features used to identify and characterize properties, namely: (1) location; (2) dimension; (3) function; (4) age; (5) brand; and (6) aesthetics. Location is a key attribute of real estate products. However, Barbosa (2021, p. 25) notes that, while *"the critical success factor for real estate is location*", it should not be seen as something static because location value is affected by trends within societies. Similarly, the dimension of real estate products conditions the market in which they are inserted and allows agents to identify any actual potential markets. Residential properties cannot be compared with buildings serving different functions. Each space's function is also an important attribute of real estate in terms of market segmentation as function determines the way users utilize space. Malpezzi (1990), Brill and Raco (2021), and Costa et al. (2021) specifically associate cost factors with functionality characteristics. The age of real estate products requires objective analysis in the same way that their current state of conservation needs to be assessed (Ferreira et al., 2022; Pinto et al., 2022). In addition, brand is essential to correlate properties with the relevant market's perception of their brand's quality. This attribute is investors' responsibility insofar as a good name in the market is the result of careful, judicious work, but, if brands do not evolve to reflect users' needs, real estate products can quickly be perceived as obsolete and disqualified. Finally, aesthetics, similar to brand, depend on the current market's interpretation and acceptance (Geltner et al., 1992; Ribeiro et al., 2017).

The real estate sector has a close connection with the financial markets when it is analyzed based on real estate market trends. Property value depends on real estate evaluations and risk analyses, thereby directly impacting the economy in question (Mera & Renaud, 2000; Vanags & Butane, 2013; Brill & Raco, 2021). Real estate and financial markets interconnect to form points of convergence in forecasts associated with the capital markets (*i.e.*, in which owners' offers of assets are inserted). Other intersecting points occur in forecasts driven by local or national economies and demographic and technological factors (*i.e.*, in which buyers' demands are incorporated). According to Geltner et al. (1992), Pires et al. (2018), and Barbosa (2021), this interconnection also appears in predictions of how stimulation of real estate development will affect the overall economy.

Growing concerns about the environment and sustainable policies are part of the current reality of real estate projects (Pérez-Gladish et al., 2021). Sustainability in real estate projects entails guaranteeing the present generations' needs are met without compromising future generations' well-being (Pivo, 1996; Brito et al., 2019). Real estate investment should thus emphasize sustainable competitiveness driven by economic growth, social cohesion, employment development, and resource management combined simultaneously in an efficient and sustainable way (Vanags & Butane, 2013; Correia et al., 2020; Pérez-Gladish et al., 2021). To this end, measurement and structuring techniques are needed to facilitate conscious, reliable decision making about large real estate investments. Table 1 presents a summary of some previous studies of this issue, including their respective contributions and limitations.

Real estate investment agents are currently under increasing pressure to adjust projects to match clients' needs and wishes. However, the ability to identify their key requirements and collaborate in decision-making processes depends directly on constant measurements of variables and evaluation criteria. To identify the best methods for assessing large real estate investments, investment managers should first carefully collect preliminary information to understand clients' (*i.e.*, investors and/or financiers) real estate needs, market trends (*i.e.*, either real estate or financial markets), buyers' needs, and market prospects. Second, agents have to structure the decision problem by defining the relationships between variables and selecting the evaluation methods to be used. Third, meetings need to be held with stakeholders and facilitators in order to prepare analyses–and re-analyses of previous steps–in order to structure and prioritize the decision criteria. In the last three steps, decision makers should measure these criteria, examine the results of selected methods, and consolidate evaluations to make recommendations to improve future applications.

In this context, investment managers should understand the limitations of the various methodologies available (see Table 1) to ensure a more appropriate selection of

Table 1. Prior studies of valuation of (large) real estate investments

Authors	Methods	Contributions	Limitations
Romero (1996)	Multicriteria decision making	Identifies the problems associated with the need to balance environmental economics and assessments of improvements, which contributes to an innovative methodology for evaluating natural assets. Connects traditional analysis systems with a utility function to balance economic and environmental objectives.	Part of the results are only valid in bi-criteria analysis. The multi-attribute utility function needs to be identified.
Zanazzi (2003)	Analytic hierarchy process (AHP) and discrete multicriteria decision making (DMDM)	Specifies anomalies and possible improvements. Evaluates preferences through comparisons between alternatives. Uses positive heuristics corresponding to cognitive processes applied to non-rational decisions and ignores part of the information available to make choices or decisions faster and easier.	Fundamental conditions for AHP diverge from those for DMDM. If the hierarchy is incomplete, skewed weights can result. An extensive list was generated of comparisons between all possible pairs of elements.
Zhang and Yang (2012)	Fuzzy comprehensive evaluation, Delphi, and AHP	Allows for a comparative analysis of real estate investment risks to ensure more reliable assessments. Serves as a guideline for risk factors and formulates important forecasts for real estate investors. Determines each factor's level of importance to construct a comprehensive real estate investment risk assessment system.	The application should use various methods to prove effective.
Battisti et al. (2018)	Multicriteria decision analysis	Uses decision-support systems as a strategic tool to make decisions associated with transformations in real estate management processes. Identifies evaluation techniques recognized by the European Community that speed up decision making based on multicriteria factors. Provides ways to identify relevant stakeholders. Assigns essential values to the identified criteria.	The aggregated data condition from the outset the method used because of the application's specificities.
Faria et al. (2018)	Measuring attractiveness by a categorial based evaluation technique	Facilitates evaluations of subjective themes. Achieves a more realistic result by combining cognitive maps with attractiveness measurement. Assumes a constructivist posture that allows for a constantly developing learning process (*i.e.*, a constant evolution of knowledge).	Accurate models are difficult to develop when associated with subjective themes. The methodology implies the involvement of experts and facilitators to lead the group.
Franco and Macdonald (2018)	Cultural heritage and geographic information system (GIS)	Demonstrates the impact GIS can have on property evaluations in terms of attractiveness and value by identifying the pattern of location prices, which enables spatial correlation. Verifies that the variables associated with property economic value estimates also include connections with the entire economy, historical surroundings, and location.	Inferences are difficult to make regarding the role of heritage since the measures adopted for preserving heritage are not standard across municipalities.
Brito et al. (2019)	Fuzzy cognitive mapping and Choquet integral (CI)	Identifies key points in how to optimize city level of sustainability. Uses cognitive mapping to allow for simple, broad-spectrum applications. Incorporates the CI to enable the inclusion of qualitative criteria simultaneously with quantitative criteria and model their interdependence. Develops a simple application of the two chosen methods to facilitate extrapolation to a wide range of applications.	The lengthy process implies the expert panel should be strongly dedicated to guaranteeing reliable results. A constructivist approach was used, so the process reflects constant evolution and cannot present an ideal solution. Software needs to be developed that optimizes processes to speed up results.
Ribera et al. (2020)	AHP	Selects evaluation criteria and sub-criteria, including a definition of their weights and scores. Creates a model that can be adapted to other cases (*e.g.*, promoting the revitalization of cities based on viable, optimized, and compatible alternatives). Implements algorithms that guarantee the highest and best use.	Definitions and choices require a multidisciplinary study, which indicates from the outset that it has to be a lengthy, careful process.

techniques according to the requirements and objectives of each investment project. Two main categories of limitations have been identified in the existing literature on evaluating significant real estate investments. The first is the unclear way in which the criteria used to assess large property investments have been identified, while the second is the unscientific and/or unrealistic methods used to calculate the criteria's weights, which can lead to significant errors in estimations of trade-offs (Ribeiro et al., 2017; Ferreira et al., 2022).

Decision makers need to manage and improve investment performance, so they seek to assess specific variables using tools and measurement systems that can provide qualitative results that are subsequently quantified. Understanding the particularities of each analysis system can help investors identify which model best suits the decision problem at hand. Qualitative results should then be translated into quantitative criteria to facilitate the measurement of available alternatives (*i.e.*, large real estate investments). To this end, the present study uses cognitive mapping techniques to select the evaluation criteria and overcome the first category of recurrent limitations in the literature. The BWM is subsequently applied to calculate the trade-offs between criteria to avoid the second type of limitations identified.

2. Methodological background

According to Marttunen et al. (2017, p. 1), *"effective problem structuring is critically important* […] *as the subsequent phases of analysis are strongly influenced by the structuring process"*. The current research combined VFT (Keeney, 1996), cognitive mapping, and the BWM (Rezaei, 2015) to organize and analyze the decision problem in question.

2.1. VFT and cognitive mapping

The methods chosen to carry out multicriteria assessments can only be effective if the information collected initially is authentic in terms of having practical impacts on the decision problem's resolution. Keeney (1996, p. 537) suggests that *"alternatives are relevant only because they are means to achieve values"*. Decision-making support processes should thus identify options that reflect significant stakeholders' values and that are based on specialists who collectively share opinions formed by their vision and knowledge about the problem (Zimmermann & Eber, 2017). Knowledge is an integral part of analyzing processes and issues as it contributes to the identification of better alternatives for solving decision problems (Keeney, 1996). This analysis results in a stronger awareness of how the mind functions and consequently changes behaviors because the decision-making process involves collaborative group work based on a shared understanding of the interdependencies of variables associated with a given decision problem (Eden, 2004; Faria et al., 2018; Ferreira et al., 2022).

Cognitive mapping techniques are commonly used to structure and stimulate discussion among specialists in order to meet the objectives of the VFT approach (Ferreira et al., 2016, 2022). Cognitive maps are mental representations that allow decision makers to identify concepts and/or variables (Eden, 2004). These techniques clarify the connections between variables with arrows and define the effect of these relationships on the decision problem with positive (+) or negative (–) signs. Cognitive maps are characterized by diversity (*i.e.*, large interdisciplinary scope) and the absence of restrictions. The results are similar to that of mind maps (*i.e.*, hierarchical development and tree structure) and concept maps (*i.e.*, aggregations of contact points between topics establishing the latter's interrelationships) in terms of usefulness. However, cognitive maps represent an added value for those seeking to structure complex decision problems and identify potential solutions (Lousada et al., 2021). Ferreira et al. (2016) and Ribeiro et al. (2017) observe that these maps' descriptive and reflective functions are their main advantages, which make thinking about decision problems easier and facilitate their resolution through the creation and development of new approaches.

Simplifying the basis of problems and/or relevant processes is an essential step toward making the best possible decision. Cognitive mapping minimizes the risk of decisions that are harmful to organizations/projects insofar as the resulting maps guarantee that appropriate strategic plans can be made for how to achieve the objectives of each project. Real estate investment projects can be understood as valuable to society at large as they transform the surrounding areas and the population that uses the properties. The complex task of evaluating the variables that affect sizeable real estate projects is made easier by cognitive maps that are developed by groups of specialists from different relevant fields. Sharing knowledge and values during decision making thus provides added value, as previously demonstrated in research on other decision problems (*cf.* Keeney & Raiffa, 1975; Ferreira et al., 2016; Faria et al., 2018; Brito et al., 2019). Sousa (2005) argues that investment projects should use resources in ways that respect specific conditions. Experts should decide which economic principles, if any, should guide their decisions about real estate investments in order to guarantee better results at a lower cost. These projects need to be understood as responsible applications of resources that have repercussions at a macroeconomic and social level. Using the VFT approach and cognitive mapping, decision makers can identify variable interrelationships and thus the best project management strategies.

2.2. Best-worst method

Measurement is a fundamental tool when decisions are defined and implemented, but quantification cannot be treated as a static process. Measurement should be understood as facilitating constant monitoring and reviewing of variables to improve management practices and decision-

making processes. Multicriteria evaluations, in particular, are conducted to estimate the weights of different criteria so that decision making becomes more objective and based on realistic analyses.

The BWM helps experts measure and classify alternatives to find the best compromise between what is desired and what can be achieved through the comparison of pairs of previously defined criteria. This method was developed by Rezaei (2015) and gradually updated (Rezaei, 2016) to deal with decision-making problems that involve various variables by evaluating alternative solutions and their relationship with specific criteria. Decision makers use previously identified criteria to define the best, the most desirable, or the most critical option and the worst, the least desirable, or the least essential solution based on comparisons of the alternatives suggested. The criteria's weights are also estimated because these condition the experts' definition of the best alternative. This comparative method has been found to offer better performance and consistency than other multicriteria methods (Celik & Gul, 2021; Mendes et al., 2022; Silva et al., 2022).

According to Rezaei (2015), the BWM involves six steps. Step one is to identify the evaluation criteria $\{c_1, c_2, ..., c_n\}$. Step two is to define the best (B) (or most important) criterion and worst (W) (or least relevant) criterion. In step three, the decision makers evaluate the criteria using a scale ranging from 1 to 9, on which "1" represents a criterion's equal importance to B and "9" implies the criterion is of greater importance than B. In the preference system, this criterion is ranked as the most important compared to the other options (*i.e.*, best-to-others) using Equation (1):

$$A_B = (a_{B1}, a_{B2}, ..., a_{Bn}), \tag{1}$$

in which a_{Bn} corresponds to the level of preference over B and $a_{BB} = 1$. Step four requires the decision makers to apply another scale from 1 to 9, on which "1" represents a criterion's equal importance to W and "9" implies the criterion is less important than W. In the preference system, this criterion is the least important compared to other options (*i.e.*, others-to-worst), as expressed by Equation (2):

$$A_W = (a_{1W}, a_{2W}, ..., a_{nW})^T, \tag{2}$$

in which a_{nW} corresponds to the level of preference in relation to W and $a_{WW} = 1$. Step five is to determine the criteria's optimal weights $(w_1^*, w_2^*, ..., w_n^*)$. That is, for each pair $\frac{w_B}{w_j}$ and $\frac{w_j}{w_W}$, $\frac{w_B}{w_j} = a_{Bj}$ and $\frac{w_j}{w_W} = a_{jW}$. To satisfy this condition, the maximum absolute difference must be minimized across all criteria j by using Equation (3):

$$\begin{aligned} &min\, max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\} \\ &s.t. \\ &\sum_j w_j = 1 \\ &w_j \geq 0, for\ all\ j \end{aligned}. \tag{3}$$

The decision problem can also be restructured using Equation (4) to determine the criteria's respective weights $\xi^*(w_1^*, w_2^*, ..., w_n^*)$:

$$\begin{aligned} &min \xi^L \\ &s.t. \\ &\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi^L, for\ all\ j \\ &\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi^L, for\ all\ j \\ &\sum_j w_j = 1 \\ &w_j \geq 0, for\ all\ j \end{aligned}. \tag{4}$$

The last step is to check the results' consistency. This procedure evaluates the method's reliability by comparing the weight ratios obtained with Equation (5):

$$Consistency\ ratio = \frac{\xi^*}{Consistency\ index}, \tag{5}$$

in which ξ^* represents the consistency index. Thus, the closer its value gets to 0, the more consistent the analysis becomes.

Once the six steps of the BWM system are completed, the decision makers need to examine the results' potential contributions to, in the present case, the evaluation of large real estate investments. Defining the problem's structure by identifying the best and worst criteria facilitates more precise comparisons (Mohammadi & Rezaei, 2020). Decision makers can also identify two clear vectors based on the scale of integers, which makes their analysis less redundant and faster (Foroozesh et al., 2022).

The BWM has been widely accepted by the academic community. However, any applications should take place within an appropriate theoretical framework, and the limitations and potential uses of the BWM need to be compared to other available assessment methods. The BWM has been found to provide superior performance in terms of ensuring evaluation criteria's consistency (Rezaei, 2015) as a structured peer-to-peer comparison allows for more consistent comparisons of criteria and more meticulous collection of comparison data. The results are thus more reliable (Rezaei, 2015). According to Wang et al. (2020), Mendes et al. (2022) and Silva et al. (2022), this method should be applied by a group of specialists in different related areas to provide further credibility to the results and ensure more precise solutions. Overall, the BWM provides advantages in evaluations of large real estate investments that can overcome some of the limitations of prior research. This method is simple to apply, and its results are more reliable with regard to broad-spectrum applications. Thus, the BWM was chosen for the present study.

3. Application and results

A multicriteria system for assessing large real estate investments was developed using VFT, cognitive mapping, and the BWM in two sessions held with a panel of experts.

The decision-making process had three phases: (1) structuring of the decision problem with VFT and cognitive mapping; (2) evaluating the alternatives (*i.e.*, large real estate investments) using the BWM; and (3) formulating recommendations.

The first phase could only start after the panel of experts (*i.e.*, decision makers) was recruited as its composition was of great importance to the information generated, which would have a strong impact on the final results. The more solid these specialists' expertise was, the more powerful the decision-problem analysis and elaboration of recommendations could become in the final phase. The sessions took place in the Zoom platform and used the Miro platform (see https://miro.com/) to facilitate interactions between all the participants based on the "post-its technique" (Ackermann & Eden, 2001).

3.1. Structuring phase: participants and procedures

The first session started with the introduction of the panel members and the facilitator who guided the sessions, including clarifying everyone's prior experience. Next, the facilitator presented the research objectives and the methods to be used in the structuring phase (*i.e.*, VFT and cognitive mapping following the Strategic Options Development and Analysis (SODA) methodology (Ackermann & Eden, 2001)). The experts were then asked to identify any criteria that could answer the following trigger question: *"Based on your knowledge and professional experience, what criteria do you consider important to evaluations of sizeable real estate investments?"*.

The decision makers wrote down their criteria on post-it notes by sharing experiences, values, and ideas with regard to what can affect assessments of large real estate investments. During this process, three guidelines were followed. First, only one criterion was written on each post-it note. Second, whenever a criterion had a negative relationship with the trigger question, a minus (–) sign had to be included on the relevant note. Last, the goal was to identify at least 100 criteria, but only criteria collectively validated by the panel could be considered.

This first procedure resulted in 166 evaluation criteria, after which they were grouped into clusters (*i.e.*, areas of interest). The seven clusters were labelled as follows: *Location and accessibility* (C1); *Legislation and urban property* (C2); *Taxation* (C3); *Big questions: macro vision* (C4); *Economy and finance* (C5); *Sustainability* (C6); and *Socioeconomic factors* (C7). The criteria within each cluster were then analyzed by the panel and organized within each area of interest into a hierarchy by order of importance.

The information collected in the first session was translated into a group cognitive map by the *Decision Explorer* software (http://www.banxia.com) (see Figure 1). The map was presented to the experts at the beginning of the second session for further analysis and validation. This procedure was process-oriented, so the development of the map was shaped by the specialists recruited. Thus, subjectivity was assumed to be present from the beginning, and a facilitator was included to control this component.

3.2. Evaluation phase

The second group session was conducted with the same panel of decision makers. The BWM was explained, and the panel was apprised of its importance as a way to assess the performance of large real estate projects. The first step was to identify the most significant decision criteria using the nominal group technique (NGT) and multi-voting method. Table 2 presents the decision criteria selected in each cluster for the BWM application.

After the expert panel selected the criteria to be analyzed using the BWM, they were asked to calculate the clusters' weights. The relationships between the areas of interest were

Table 2. Criteria selected for analyses

Location and accessibility	Property and urban planning legislation	Taxation	Big questions: macro vision	Economy and finance	Sustainability	Socioeconomic factors
Good accessibility Location Type of investment: residential and/or commercial Proximity to city centers Updated spatial planning system Urban consolidation perspective Assignment to activity sector	Municipal master plan's permissiveness Construction legislation Delays in project approval (–) Regulatory restrictions (–) Urban legislation: land, property classification, and available infrastructure Licensing delays (–) Acquisition conditions offered to end customers	Tax breaks Incentives for international investment (*e.g.*, Golden Visa) Return rate Tax legislation, taxes, and exemptions for sellers and/or buyers Real estate investment funds	Investors' needs and expectations Economic development potential Environmental issues Understanding of market cycles Economic factors Social factors: need, scarcity, and fashion Suitable land: location and dimension	Zone's economic growth Profitability Initial project implementation expenses Ability to obtain bank credit Investment recovery time Use of equity, debt, and financing capital Medium-term profit	Sustainability logic Presence of parks and green areas Environmental concerns Multifunctional areas Sun exposure and prevailing winds Sustainable and recyclable building materials Environmentally certified materials	Segmentation of real estate market Labor availability Jobs Construction quality Contribution to social goals

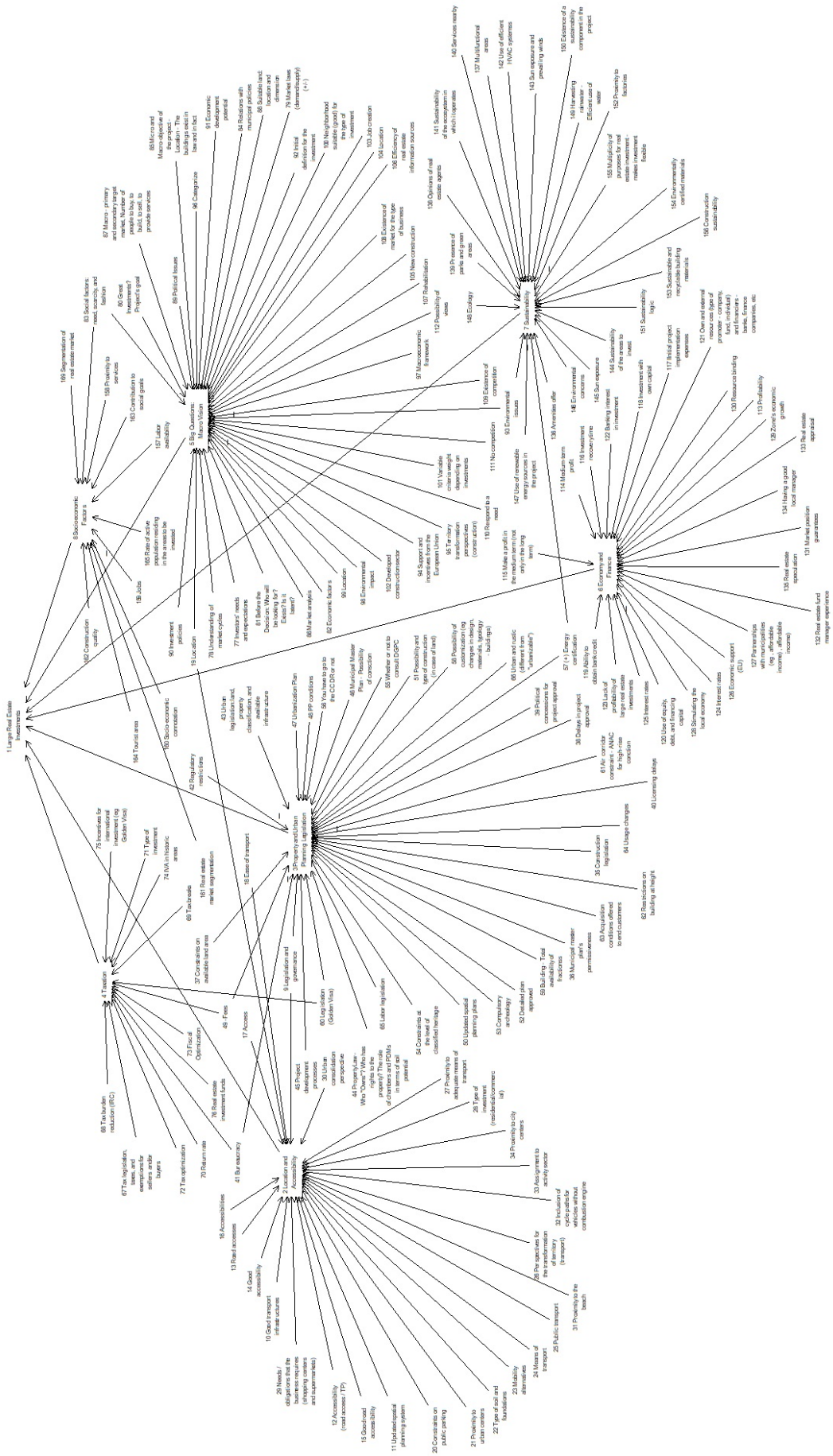

Figure 1. Group cognitive map

compared pairwise (*i.e.*, inter-cluster analysis), and then the criteria within each cluster were evaluated (*i.e.*, intra-cluster analysis). The analyses were based on identifying the best cluster/criterion and worst cluster/criterion to define the best-to-others and worst-to-others vectors on a scale ranging from 1 to 9. Once the BWM technique had been applied, the consistency of results (*i.e.*, based on the key success index) could be checked. The inter-cluster analysis revealed that C4 has the greatest impact on evaluations of large real estate projects. In contrast, C3 was found to be the worst given its visibly reduced weight compared to the other clusters (see Table 3). Figure 2 presents the clusters' weights as assigned by the panel.

The decision makers were next asked to evaluate previously identified alternatives (*i.e.*, 10 large real estate investment projects) using the BWM, cluster weights, and most significant criteria selected in each cluster. Table 4 shows the partial assessments of each alternative A_x (with $x = 1, 2,\ldots, 10$). Figure 3 presents the overall scores.

Figure 3 shows that tourism real estate projects A7 and A6 (*i.e.*, in green) have the highest scores as compared to alternatives A5 and A8 due to the intrinsic higher quality of their construction and surroundings. A1, in the heart of Lisbon, is nearly as important despite being one of the housing projects alternatives (*i.e.*, in yellow). In contrast, A2 has the lowest score of all the housing investment opportunities. The blue bar corresponds to the single alternative involving offices, while the gray bar is the only commercial property. The housing projects analysis provided a more balanced comparative analysis between the clusters, as shown in Figure 4.

An analysis of Figure 4 reveals that C4 has the most significant impact on assessments of the housing investment alternatives before they enter into the design phase.

Table 3. Best-worst method application to seven clusters

Number of clusters = 7	C1	C2	C3	C4	C5	C6	C7
Names of clusters	Location and accessibility	Legislation and urban property	Taxation	Big questions: macro vision	Economy and finance	Sustainability	Socioeconomic factors
Best cluster	–	–	–	Big questions: macro vision	–	–	–
Worst cluster	–	–	Taxation	–	–	–	–
Best-to-other vector	Location and accessibility	Legislation and urban property	Taxation	Big questions: macro vision	Economy and finance	Sustainability	Socioeconomic factors
Big questions: macro vision	4	1	4	1	2	1	2
Others-to-worst	–	–	Taxation	–	–	–	–
Location and accessibility	–	–	7	–	–	–	–
Legislation and urban property	–	–	9	–	–	–	–
Taxation	–	–	1	–	–	–	–
Big questions: macro vision	–	–	8	–	–	–	–
Economy and finance	–	–	5	–	–	–	–
Sustainability	–	–	7	–	–	–	–
Socioeconomic factors	–	–	7	–	–	–	–
Weights	0.063829787	0.170212766	0.021276596	0.255319149	0.127659574	0.234042553	0.127659574
Key success indicator	0.085106383						

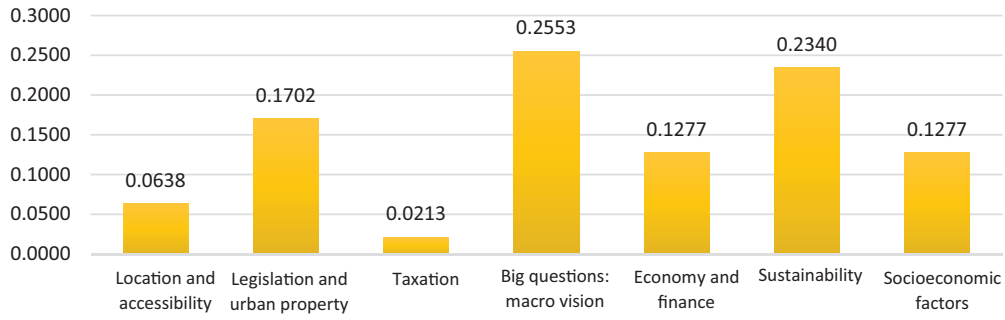

Figure 2. Clusters' weight

C2 and C6 are also quite important. Regarding C5, the construction costs associated with these projects are high, but these expenses are compensated for by the profitability of sales made based on the expectations generated by social–and other–media. The same analysis was carried out for the tourism alternatives (see Figure 5).

Compared to C7, C3 has a relatively consistent low weight in the joint analysis shown in Figure 5. Various observations can be made and additional data extracted from this comparison of the clusters and/or tourism property alternatives, although caution needs to be taken to avoid comparing properties with different uses and/or purposes.

The next subsection presents the consolidation/validation of the proposed analysis model by a neutral expert who did not participate in the two earlier sessions. This final meeting facilitated the formulation of recommendations based on this specialist's evaluation of the panel's group work.

Table 4. Best-worst method application to 10 alternatives

Clusters	Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Location and accessibility	Good accessibility	8	5	8	7	7	8	8	4	7	9
	Location	9	7	9	6	8	9	9	7	7	9
	Type of investment: residential and/or commercial	8	8	7	8	9	8	8	6	8	9
	Proximity to city centers	9	7	8	7	8	9	9	5	8	9
	Updated spatial planning systems	7	8	7	7	9	8	8	8	8	9
	Urban consolidation perspective	8	8	7	7	9	9	9	5	8	9
	Assignment to activity sector	9	8	8	8	8	9	9	6	9	9
	Cluster total	0.522	0.451	0.512	0.458	0.526	0.539	0.529	0.401	0.493	0.563
Property and urban planning legislation	Municipal master plan's permissiveness	8	7	7	8	8	9	9	5	8	8
	Construction legislation	8	6	7	8	8	9	8	6	9	8
	Delays in project approval	7	5	6	7	6	8	8	5	7	5
	Regulatory restrictions	8	5	6	7	7	8	8	5	7	5
	Urban legislation: land, property classification, and available infrastructure	9	6	7	7	8	8	8	5	8	7
	Licensing delays	7	6	7	7	6	8	8	5	6	5
	Acquisition conditions offered to end customers	9	7	7	8	8	9	8	8	8	7
	Cluster total	1.357	0.988	1.113	1.247	1.266	1.383	1.370	0.841	1.264	1.088
Taxation	Tax breaks	6	7	5	5	7	7	9	7	6	7
	Incentives for international investment (*e.g.*, Golden Visa)	8	6	5	6	9	9	8	9	5	7
	Return rate	7	6	6	6	8	7	9	8	8	5
	Tax legislation, taxes, exemptions for sellers and/or buyers	6	6	5	5	7	8	8	7	8	7
	Real estate investment funds	7	7	5	7	8	7	7	8	9	8
	Cluster total	0.141	0.124	0.120	0.131	0.164	0.155	0.172	0.160	0.154	0.125
Big questions: macro vision	Investors' needs and expectations	8	7	8	8	9	8	8	8	7	8
	Economic development potential	9	7	8	8	8	9	9	9	8	9
	Environmental issues	7	6	6	5	7	8	9	8	9	8
	Understanding market cycles	8	7	8	7	6	8	8	8	8	7
	Economic factors	8	7	7	8	8	8	9	8	8	8
	Social factors: need, scarcity, and fashion	8	7	8	7	7	7	8	7	7	8
	Suitable land: location and dimension	9	8	9	7	8	8	9	8	9	9
	Cluster total	2.093	1.777	2.028	1.847	2.026	2.098	2.156	2.016	1.967	2.141
Economy and finance	Zone's economic growth	8	8	8	6	8	8	9	6	7	8
	Profitability	7	7	7	7	8	7	8	8	7	7
	Initial project implementation expenses	7	7	7	8	6	9	9	8	7	6
	Ability to obtain bank credit	8	7	7	8	8	8	9	8	8	7
	Investment recovery time	8	7	7	8	8	8	8	8	8	5
	Use of equity, debt, and financing capital	8	6	7	8	8	8	9	8	8	9
	Medium-term profit	8	7	7	8	7	8	7	8	8	5
	Cluster total	0.927	0.874	0.873	0.967	0.960	0.970	1,002	0.982	0.937	0.771

End of Table 4

Sustainability	Sustainability logic	6	8	6	7	7	9	8	8	7	7
	Presence of parks and green areas	7	8	7	7	5	6	6	9	6	6
	Environmental concerns	8	8	7	7	6	8	8	9	7	7
	Multifunctional areas	8	8	7	7	6	8	9	6	6	7
	Sun exposure and prevailing winds	7	7	6	5	8	9	8	7	6	8
	Sustainable and recyclable building materials	7	7	5	6	7	7	7	7	6	8
	Environmentally certified materials	7	6	5	7	6	7	7	7	7	7
	Cluster total	1.623	1.613	1.383	1.564	1.513	1.765	1.763	1.707	1.520	1.660
Socioeconomic factors	Segmentation of real estate market	9	7	7	8	8	9	8	8	8	8
	Labor availability	8	8	7	7	7	8	9	8	8	8
	Jobs	8	8	7	7	8	9	9	8	8	9
	Construction quality	9	7	7	8	8	9	9	8	8	8
	Contribution to social goals	4	8	7	4	6	7	7	5	5	8
	Cluster total	0.737	0.980	0.911	0.672	0.845	0.933	0.971	0.752	0.796	0.998
	Overall score	7.400	6.806	6.939	6.888	7.301	7.843	7.963	6.858	7.132	7.345

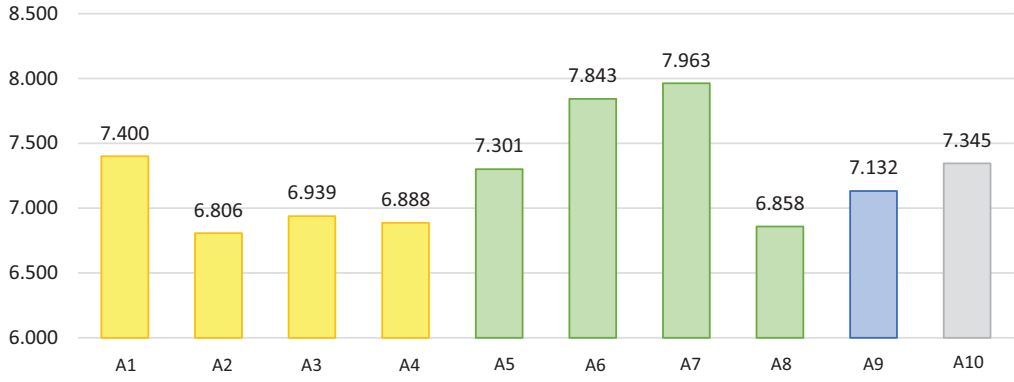

Figure 3. Alternatives' overall score

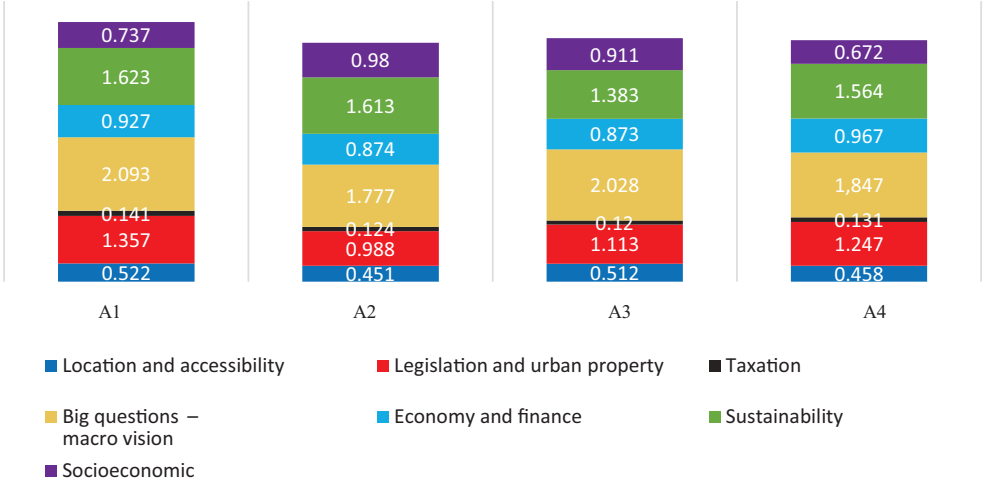

Figure 4. Housing project alternatives by clusters

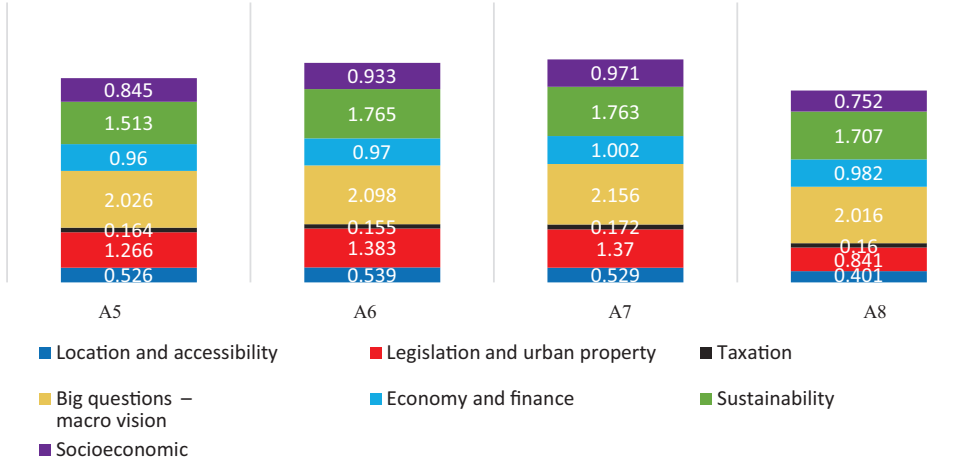

Figure 5. Tourism project alternatives by clusters

3.3. Consolidation, limitations, and recommendations

To validate the results obtained in this study, the decision-support model was assessed by an independent decision maker from the *Instituto da Habitação e da Reabilitação Urbana* (IRHU) (Institute of Housing and Urban Rehabilitation). This professional is a member of the IRHU Board of Directors and can be considered independent/neutral because he had not participated in the previous group meetings.

This final session was organized into four distinct parts. First, the interviewer contextualized the topic under study and presented the methodologies applied (*i.e.*, VFT, cognitive mapping, and the BWM). Second, the results of the two earlier phases were displayed and discussed with the expert. Third, he then evaluated the practical applicability of the proposed model. Last, the interviewee made suggestions for how to improve the model, among other final comments.

During this meeting, the analysis of the results included addressing questions that had arisen during the previous sessions with the expert panel regarding the model's intended use in evaluations of large real estate investments. The participants understood that this study had to be based on projects that had already been completed as data on real estate investment opportunities still in the development phase were not available for analysis. The results presented in the validation session at the IRHU were thus intended to demonstrate the potential of the decision-support system as a tool to evaluate large real estate projects.

The interviewee was asked what needed to be done to implement the proposed analysis model in practice and who could apply the procedures. He answered immediately that it *"should be implemented by private individuals and possibly by those who conduct risk assessment in banking"* (in his words). His opinion was unsurprising given that, in the earlier stages of the system development, the idea had already come up that this tool could be used in internal financing risk analyses or even risk assessment by external financing entities. This expert further suggested that the model could be improved by *"reducing the number of criteria in order to not lose focus and to make the process more operational"* (also in his words). He also noted *"the possibility of working for shorter intervals to ensure greater homogeneity in the classifications"* (again in his words).

Overall, the final session went well as it opened doors for future applications of the analysis system. Still, the complementary stance of our study should be highlighted, making clear that the aim is not one of substitution of previous methods or models, but rather their augmentation. Because our approach allows for the addition of new information at any time, the proposed model is not only robust, but also versatile. This means that the use of the methodology proposed in this study allowed for the construction of a different, but complementary model to those already existing, and resulted in the design of a transparent, simple and well-informed system, comprising both objective and subjective components.

Conclusions

A multicriteria evaluation system was developed to help decision makers conduct pre-project evaluations of real estate investments. This tool can provide a greater degree of objectivity and validity to investment management processes, as well as generating competitive advantages over other players in the same markets. Investors should take responsibility for ensuring more efficient resource management, increasing their objectivity without compromising receptivity, and applying new analysis techniques based on empirical research. This study thus sought to create a decision-support mechanism that can be used in assessments of large real estate projects.

The existing literature provides evidence of a clear association between real estate and economic cycles in developed countries. The importance of real estate markets to national economies is clear at a business and social level, so construction projects should use their resources sustainably and responsibly. To fill gaps in prior research

on this topic, the present study applied a combination of methodologies that take a constructivist approach to decision making, are simple to apply, and produce results of substantive value to diverse economies. An expert panel was recruited from a variety of relevant fields to facilitate an exchange of ideas and the development of a group conceptual map that shows which factors can affect real estate investors' decisions. The procedures followed helped these specialists identify the main variables that need to be considered in evaluations of large real estate projects, thereby making a substantive contribution to investment management practices.

The cognitive map developed in the structuring phase based on VFT was complemented by an evaluation of 10 building project alternatives using the BWM. The analyses focused on identifying and quantifying the weight of each variable and its real impact on assessments of investment opportunities. This approach to evaluating alternatives used comparisons to increase the tool's applicability in multiple contexts, such as success of previous projects, internal financing risk analyses, or risk assessments of external financing entities.

This study's main limitation is a dependence on the specific expertise of the decision-maker panel, but this feature can also be seen as an advantage. To consolidate the results, researchers could hold new sessions with a different panel of experts. In addition, other multicriteria evaluation techniques could be applied to check whether the choice of methodologies in the present investigation comes the closest to an optimal combination. Future studies could also apply the analysis system in international contexts to increase this tool's usefulness in evaluations of large real estate investments as the variables involved are sufficiently well known in large-scale projects worldwide.

The proposed model represents an advance in prior research on–and the application of multicriteria evaluation methods to–the real estate sector. The present study developed a tool that can help decision makers improve their resource management in terms of assessing property investments. As Gama (2012, p. 11) so aptly writes, *"what counts is not the act of measuring itself, but what is achieved through it"*.

Acknowledgments

This work was partially funded by the Portuguese Foundation for Science and Technology (Grants UIDB/00315/2020 and UIDB/04630/2020). Records of the expert panel meetings, including photographs, software output, and non-confidential information, can be obtained from the corresponding author upon request. The authors gratefully acknowledge the contribution of the panel members: Fábio Andrade, José Coutinho Ribeiro, Maria dos Anjos Ramos, Marina Zueva, Miguel Brito Correia, Miguel Morais Sarmento, Ricardo Garcia Pereira and Sónia Gil Fernandes. Also, we appreciate Luís Gonçalves, board member of the Institute of Housing and Urban Rehabilitation (IHRU in Portuguese), Portugal, for his availability and the insights provided during the consolidation phase.

References

Ackermann, F., & Eden, C. (2001). SODA – Journey making and mapping in practice. In J. Rosenhead & J. Mingers (Eds.), *Rational analysis for a problematic world revisited: problem structuring methods for complexity, uncertainty and conflict* (pp. 43–60). Jonh Wiley & Sons.

Archer, W., Ling, D., & McGill, G. (1997). Demographic versus option-driven mortgage terminations. *Journal of Housing Economics*, *6*, 137–163. https://doi.org/10.1006/jhec.1997.0206

Bana e Costa, C., Stewart, T., & Vansnick, J. (1997). Multicriteria decision analysis: some thoughts based on the tutorial and discussion sessions of the ESIGMA meetings. *European Journal of Operational Research*, *99*, 28–37. https://doi.org/10.1016/S0377-2217(96)00380-3

Barbosa, J. (2021). *Guia do investimento imobiliário*. Principia Editora.

Battisti, F., Chiovitti, A., & Guarini, M. (2018). A methodology for the selection of multi-criteria decision analysis methods in real estate and land management processes. *Sustainability*, *10*(2), 1–28. https://doi.org/10.3390/su10020507

Brill, F., & Raco, M. (2021). Putting the crisis to work: the real estate sector and London's housing crisis. *Political Geography*, *89*, 102433. https://doi.org/10.1016/j.polgeo.2021.102433

Brito, V., Ferreira, F., Gladish, B., Govindan, K., & Meidutė-Kavaliauskienė, I. (2019). Developing a green city assessment system using cognitive maps and the Choquet integral. *Journal of Cleaner Production*, *218*, 486–497. https://doi.org/10.1016/j.jclepro.2019.01.060

Celik, E., & Gul, M. (2021). Hazard identification, risk assessment and control for dam construction safety using an integrated BWM and MARCOS approach under interval type-2 fuzzy sets environment. *Automation in Construction*, *127*, 103699. https://doi.org/10.1016/j.autcon.2021.103699

Correia, J., Ferreira, F., Meidutė-Kavaliauskienė, I., Pereira, L., Zopounidis, C., & Correia, R. (2020). Factors influencing urban investment attractiveness: an FCM-SD approach. *International Journal of Strategic Property Management*, *24*(4), 237–250. https://doi.org/10.3846/ijspm.2020.12384

Costa, J., Ferreira, F., Spahr, R., Sunderman, M., & Pereira, L. (2021). Intervention strategies for urban blight: a participatory approach. *Sustainable Cities and Society*, *70*, 102901. https://doi.org/10.1016/j.scs.2021.102901

DiPasquale, D., & Wheaton, W. (1992). The markets for real estate assets and space: a conceptual framework. *Real Estate Economics*, *20*(2), 181–198. https://doi.org/10.1111/1540-6229.00579

Ebrahim, M., & Hussain, S. (2010). Financial development and asset valuation: the special case of real estate. *Journal of Banking & Finance*, *34*(1), 150–162. https://doi.org/10.1016/j.jbankfin.2009.07.011

Eden, C. (2004). Analyzing cognitive maps to help structure issues or problems. *European Journal of Operational Research*, *159*, 673–686. https://doi.org/10.1016/S0377-2217(03)00431-4

Faria, P., Ferreira, F., Jalali, M., Bento, P., & António, N. (2018). Combining cognitive mapping and MCDA for improving quality of life in urban areas. *Cities, 78*, 116–127. https://doi.org/10.1016/j.cities.2018.02.006

Ferreira, F., Jalali, M., & Ferreira, J. (2016). Integrating qualitative comparative analysis (QCA) and fuzzy cognitive maps (FCM) to enhance the selection of independent variables. *Journal of Business Research*, *69*, 1471–1478. https://doi.org/10.1016/j.jbusres.2015.10.127

Ferreira, F., Spahr, R., Sunderman, M., Govindan, K., & Meidutė-Kavaliauskienė, I. (2022). Urban blight remediation strategies subject to seasonal constraints. *European Journal of Operational Research*, *296*(1), 277–288. https://doi.org/10.1016/j.ejor.2021.03.045

Foroozesh, F., Monavari, S., Salmanmahiny, A., Robati, M., & Rahimi, R. (2022). Assessment of sustainable urban development based on a hybrid decision-making approach: group fuzzy BWM, AHP, and TOPSIS–GIS. *Sustainable Cities and Society*, *76*, 103402. https://doi.org/10.1016/j.scs.2021.103402

Franco, S., & Macdonald, J. (2018). The effects of cultural heritage on residential property values: evidence from Lisbon, Portugal. *Regional Science and Urban Economics*, *70*, 35–56. https://doi.org/10.1016/j.regsciurbeco.2018.02.001

Gama, A. (2012). *Performance empresarial: conceito, abordagens e métodos de avaliação*. Porto Editora.

Geltner, D., Kluger, B., & Miller, N. (1992). Incentive commissions in residential real estate brokerage. *Journal of Housing Economics*, *2*(2), 139–158. https://doi.org/10.1016/1051-1377(92)90012-F

Keeney, R. (1996). Value-focused thinking: identifying decision opportunities and creating alternatives. *European Journal of Operational Research*, *92*(3), 537–549. https://doi.org/10.1016/0377-2217(96)00004-5

Keeney, R., & Raiffa, H. (1975). *Decision analysis with multiple conflicting objectives preferences and value tradeoffs* (IIASA Working Paper No. 75-053). Laxenburg, Austria.

Lousada, A., Ferreira, F., Meidutė-Kavaliauskienė, I., Spahr, R., Sunderman, M., & Pereira, L. (2021). A sociotechnical approach to causes of urban blight using fuzzy cognitive mapping and system dynamics. *Cities*, *108*, 102963. https://doi.org/10.1016/j.cities.2020.102963

Malpezzi, S. (1990). Urban housing and financial markets: some international comparisons. *Housing Finance International*, *27*, 971–1022. https://doi.org/10.1080/00420989020080941

Marttunen, M., Lienert, J., & Belton, V. (2017). Structuring problems for multi-criteria decision analysis in practice: a literature review of method combinations. *European Journal of Operational Research*, *263*, 1–17. https://doi.org/10.1016/j.ejor.2017.04.041

Mendes, A., Ferreira, F., Kannan, D., Ferreira, N., & Correia, R. (2022). A BWM approach to determinants of sustainable entrepreneurship in small and medium-sized enterprises. *Journal of Cleaner Production*, *371*, 1–11. https://doi.org/10.1016/j.jclepro.2022.133300

Mera, K., & Renaud, B. (2000). Asia's financial crisis and the role of real estate. *Journal of Housing Economics, 10*, 216–223. https://doi.org/10.1006/jhec.2001.0286

Mohammadi, M., & Rezaei, J. (2020). Bayesian best-worst method: a probabilistic group decision making model. *Omega, 96*, 1–8. https://doi.org/10.1016/j.omega.2019.06.001

Pérez-Gladish, B., Ferreira, F., & Zopounidis, C. (2021). MCDM/A studies for economic development, social cohesion and environmental sustainability: introduction. *International Journal of Sustainable Development & World Ecology*, *28*(1), 1–3. https://doi.org/10.1080/13504509.2020.1821257

Pinto, B., Ferreira, F., Spahr, R., Sunderman, M., & Pereira, P. (2022). Analyzing causes of urban blight using cognitive mapping and DEMATEL. *Annals of Operations Research*. https://doi.org/10.1007/s10479-022-04614-6

Pires, A., Ferreira, F., Jalali, M., & Chang, H. (2018). Barriers to real estate investments for residential rental purposes: mapping out the problem. *International Journal of Strategic Property Management*, *22*(3), 168–178. https://doi.org/10.3846/ijspm.2018.1541

Pivo, G. (1996). Toward sustainable urbanization on Mainstreet Cascadia. *Cities*, *13*(5), 339–354. https://doi.org/10.1016/0264-2751(96)00021-2

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49–57. https://doi.org/10.1016/j.omega.2014.11.009

Rezaei, J. (2016). Best-worst multi-criteria decision-making method: some properties and a linear model. *Omega*, *64*, 126–130. https://doi.org/10.1016/j.omega.2015.12.001

Ribeiro, M., Ferreira, F., Jalali, M., & Meidutė-Kavaliauskienė, I. (2017). A fuzzy knowledge-based framework for risk assessment of residential real estate investments. *Technological and Economic Development of Economy*, *23*, 140–156. https://doi.org/10.3846/20294913.2016.1212742

Ribera, F., Nesticò, A., Cucco, P., & Maselli, G. (2020). A multicriteria approach to identify the highest and best use for historical buildings. *Journal of Cultural Heritage*, *41*, 166–177. https://doi.org/10.1016/j.culher.2019.06.004

Romero, C. (1996). Multicriteria decision analysis and environmental economics: an approximation. *European Journal of Operational Research*, *96*(1), 81–89. https://doi.org/10.1016/S0377-2217(96)00118-X

Silva, J., Ferreira, F., Govindan, K., Ferreira, N., & Correia, R. (2022). A CM-BWM approach to determinants of open innovation in small and medium-sized enterprises. In *IEEE Transitions on Engineering Management* (pp. 1–18). IEEE. https://doi.org/10.1109/TEM.2022.3171591

Sousa, A. (2005). *Análise económica e financeira de projectos*. Instituto Superior de Ciências Sociais e Políticas da Universidade Técnica de Lisboa.

Vanags, J., & Butane, I. (2013). Major aspects of development of sustainable investment environment in real estate industry. *Procedia Engineering*, *57*, 1223–1229. https://doi.org/10.1016/j.proeng.2013.04.154

Wang, Y., Sun, B., Zhang, X., & Wang, Q. (2020). BWM and MULTIMOORA-based multi-granulation sequential three-way decision model for multi-attribute group decision-making problem. *International Journal of Approximate Reasoning*, *125*, 169–186. https://doi.org/10.1016/j.ijar.2020.07.003

Zanazzi, J. (2003). Anomalías y supervivencia en el método de toma de decisiones de Saaty. In L. Godoy (Ed.), *Problemas del conocimiento en ingeniería y geología* (pp. 148–170). Editorial Universitas.

Zhang, J. (2016). House price expectations: unbiasedness and efficiency of forecasters. *Real Estate Economics*, *44*, 236–257. https://doi.org/10.1111/1540-6229.12095

Zhang, M., & Yang, W. (2012). Fuzzy comprehensive evaluation method applied in the real estate investment risks research. *Physics Procedia*, *24*, 1815–1821. https://doi.org/10.1016/j.phpro.2012.02.267

Zimmermann, J., & Eber, W. (2017). Criteria on the value of expert's opinions for analyzing complex structures in construction and real estate management. *Procedia Engineering*, *196*, 335–342. https://doi.org/10.1016/j.proeng.2017.07.208