A comparative decision analysis with THOR and TODIM: rental evaluation in Volta Redonda

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Abstract
This short communication presents a comparison between the applications of THOR and TODIM to the same data. Those data were surveyed in the city of Volta Redonda, Brazil, and presented in Gomes and Rangel (2009). The multicriteria problem tackled by both methods is the evaluation of residential properties for rent. The applications of THOR and TODIM were complemented by an analysis of the sensitivity of the numerical results obtained. Both tools produce quite similar ranks, in spite of the fact that they are based on different core principles.
Keywords: Multiple criteria analysis. Real estate market. Prospect theory. Multicriteria decisions

Resumo
Nesta comunicação apresenta-se uma comparação entre aplicações dos métodos multicritério THOR e TODIM à mesma base de dados. Estes foram levantados na Cidade de Volta Redonda, no Brasil, e apresentados em Gomes e Rangel (2009). O problema de decisão multicritério abordado pelos dois métodos consiste na avaliação de imóveis residenciais para aluguel. Complementou-se as duas aplicações por meio de uma análise de sensibilidade dos resultados numéricos obtidos. Os dois métodos, embora fundamentados em princípios básicos distintos, produziram ordenações muito semelhantes.
Palavras-chave: Análise multicritério. Mercado imobiliário. Decisões multicritério

1 Introduction

This short communication presents a comparison of the THOR multicriteria decision support system (Gomes *et al*., 2008) and the TODIM method (Gomes and Rangel, 2009). The comparison is based on a case study application of both approaches. These two methods were used in order to evaluate residential properties available for rent in the city of Volta Redonda, in the State of Rio de Janeiro, Brazil. Primary data to which both methods were applied are presented in Gomes and Rangel (2009). This application concerns therefore a problem of a considerable relevance to real estate agents and renters.

2 Methodology

In the majority of cases, the criteria used to make the evaluation of residential properties are conflicting. For example, what would be most valued: a small, old house in an excellent residential neighborhood, close to the center or a large, new property with a swimming pool and leisure area in a neighborhood far from the downtown area? The TODIM method was used by Gomes and Rangel (2009) for ordering the alternatives of the residential properties for rent. After the ordering, it becomes easier to define the rental values from once previously evaluated properties. Those properties with previously defined rental values have been included in the set of alternatives and function as benchmarks. Through this short communication we compare the use of THOR against that of TODIM. Both methods are non-compensatory in the sense that tradeoffs do not occur (Bouyssou, 1986). They both use the same set of weights provide by decision agents. Those decision agents are considered experts in different aspects of the real estate evaluation problem. Both methods follow a constructive approach to decision aiding: (i) criteria weights emerge from a number of consultations to decision agents and are made explicit on the basis of their estimate of degrees of importance or relative strength; and (ii) these weights may evolve during the decision analysis as new aspects of the problem emerge during the interactions between the decision analyst and the decision agents (Roy, 1985). The two methods therefore use the same set of weights.

Those are either assigned to alternatives or to criteria, or obtained through paired comparisons between alternatives or criteria. For detailed presentations of THOR and TODIM one should refer to Gomes *et al*. (2008) and to Gomes and Rangel (2009), respectively.

3 Evaluation criteria

Eight non-redundant, rental evaluation criteria were selected for this particular application. These are listed below and described in Gomes and Rangel (2009): C1 – Location; C2 – Constructed Area; C3 – Construction Quality; C4 – State of Conservation; C5 – Number of Garage Spaces; C6 – Number of Rooms; C7 – Attractions; C8 – Security. All are maximization criteria. In other words, the higher the score obtained in the evaluation of alternatives in relation to each criterion, better the performance. In accordance with the importance given to the criteria used to evaluate the properties in the study, their respective weights were defined by the decision makers through direct valuation and later normalized. The direct valuation consisted of assigning a number between 1 and 5 to each criterion; 1 would mean 'least important' and 5 would mean 'most important'. The assignment of weights was performed by the decision makers – in this example, the realtors. The information is presented in Table 1.

Table 1: Criteria Ranks

Criterion	Description	Assigned Weights	Criteria Weights
C_1	Localization	5	0.25
C_2	Constructed Area	3	0.15
C_3	Quality of Construction	2	0.10
C_4	State of Conservation	4	0.20
C_5	Number of garage spaces	1	0.05
C_6	Number of rooms	2	0.10
C_7	Attractions	1	0.05
C_8	Security	2	0.10

4 Alternatives

The following repeats information contained in Gomes and Rangel (2009) and describes the fifteen properties used in the evaluation: A1 – A house in an average location, with 290 m^2 of constructed area; a high standard of finishing; in a good state of conservation; with one garage space, 6 rooms, a swimming pool, barbecue and other attractions; without a security system; A2 – A house in a good location; with 180 m^2 of constructed area; an average standard of finishing, in an average state of conservation, with one garage space, 4 rooms, a backyard and terrace; without a security system; A3 – A house in an average location; with 347 m^2 of constructed area, a low standard of finishing, in an average state of conservation, two garage spaces, 5 rooms, a large backyard, without a security system; A4 – A house in an average location, with 124 m^2 of constructed area, an average standard of finishing, in a good state of conservation, two garage spaces, 5 rooms, a fruit orchard, a swimming pool and barbecue, without security system; A5 – A house in an excellent location, with 360 m^2 of constructed area, a high standard of finishing, in a very good state of conservation, four garage spaces, 9 rooms, a backyard, and manned security boxes in the neighborhood streets; A6 – A house located between the periphery and the city center (periphery/average location), with 89 m^2 of constructed area, an average standard of finishing, in a good state of conservation, with one garage space, 5 rooms, a backyard, without a security system; A7 – An apartment located in the periphery, with 85 m^2 of constructed area, a low standard of finishing, in a bad state of conservation, one garage space, 4 rooms, a manned entrance hall, with security; A8 – An apartment in an excellent location, with 80 m^2 of constructed area, average standard of finishing, good state of conservation, with one garage space, 6 rooms, manned entrance hall, with security; A9 – An apartment located between the periphery and the city center (periphery/average location), with 121 m^2 of constructed area, an average standard of finishing, in a good state of conservation, no garage space, 6 rooms, without a security system; A10 – A house located between the periphery and the city center (periphery/average location), with 120 m^2 of constructed area, a low standard of finishing, in a good state of conservation, with one garage space, 5 rooms, a large backyard, without a security system; A11 – A house in a good location, with 280 m^2 of constructed area, an average standard of finishing, in an average state of conservation, with two garage spaces, 7 rooms, with an additional security system; A12 – An apartment located in the periphery, with 90 m^2 of constructed area, a low standard of finishing, in a bad state of conservation, one garage space, 5 rooms, without additional security; A13 – An apartment located in the periphery in an average location, with 160 m^2 of constructed area, a high standard of finishing, in a good state of conservation, two garage spaces, 6 rooms, with additional security features; A14 – An apartment in a good location, with 320 m^2 of constructed area, high standard of finishing, in a good state of conservation, 2 garage spaces, 8 rooms, with in addition a security system; A15 – A house in a good location, with 180 m^2 of constructed area, an average standard of finishing, in a very good state of conservation, one garage space, 6 rooms, with in addition a security system.

5 Computations with THOR and TODIM

Table 2, containing the Evaluation of Alternatives against Criteria, presents the complete evaluation of the properties studied in the analysis. Those are taken in relation to the criteria selected by the decision makers.

Table 2: Evaluation of Alternatives against Criteria

Alternatives	Criteria							
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_1	3	290	3	3	1	6	4	0
A_2	4	180	2	2	1	4	2	0
A_3	3	347	1	2	2	5	1	0
A_4	3	124	2	3	2	5	4	0
A_5	5	360	3	4	4	9	1	1
A_6	2	89	2	3	1	5	1	0
A_7	1	85	1	1	1	4	0	1
A_8	5	80	2	3	1	6	0	1
A_9	2	121	2	3	0	6	0	0
A_{10}	2	120	1	3	1	5	1	0
A_{11}	4	280	2	2	2	7	3	1
A_{12}	1	90	1	1	1	5	2	0
A_{13}	2	160	3	3	2	6	1	1
A_{14}	3	320	3	3	2	8	2	1
A_{15}	4	180	2	4	1	6	1	1

In previous work with THOR it has been demonstrated that this multicriteria decision support system must be preferentially used for dealing with pseudo-criteria as well as with quasi-criteria; those are indeed situations when THOR can be utilized at this full capacity. The use of true-criteria leads to the equality of the orderings corresponding to different evaluation contexts (Gomes, 2005; Gomes *et al*., 2008). In the present case study the notion of discordance, available in THOR and inexistent in TODIM, was not used. Using the full capacity of THOR was not needed in this case study. Computations with THOR led to a greater differentiation between the attractiveness of the alternatives. It also leads to a considerable reduction in the number of ties. Table 3 shows the final values and ordering obtained by using THOR.

Table 3: Final Values and Ordering Obtained by using THOR

Alternative	Normalized Global Value	Ordering
A_1	10.3500	4
A_2	6.6500	10
A_3	7.0000	9
A_4	8.1999	7
A_5	13.6999	1
A_6	4.9499	11
A_7	0.6999	15
A_8	8.6499	6
A_9	4.6999	12
A_{10}	3.9500	13
A_{11}	9.5000	5
A_{12}	0.8999	14
A_{13}	8.0000	8
A_{14}	11.5000	2
A_{15}	10.6000	3

When TODIM is used with data of the case study, the attenuation factor of losses θ has a value equal to 1 (Gomes and Rangel, 2009). This means that the losses will contribute with their real value to the global value. In order to implement the method, it is necessary for these performances to be normalized. The matrix of normalized performances is then called the Matrix of Normalized Alternatives' Scores against Criteria. After the implementation of the mathematical formulation of TODIM, the overall values of the alternatives obtained through normalization of the corresponding dominance measurements are presented in Table 4. This table also presents the ordering of each alternative.

Table 4: Final Values and Ordering Obtained by using TODIM

Alternative	Normalized Global Value	Ordering
A_1	0.6916	5
A_2	0.3862	10
A_3	0.3992	9
A_4	0.6210	7
A_5	1.0000	1
A_6	0.2860	11
A_7	0.0000	15
A_8	0.4407	8
A_9	0.0202	14
A_{10}	0.2127	12
A_{11}	0.8576	3
A_{12}	0.1073	13
A_{13}	0.7188	4
A_{14}	0.9372	2
A_{15}	0.6733	6

Further results from using TODIM are in Gomes and Rangel (2009) and therefore are not repeated in this short communication.

6 Comparison of results

The applications of THOR and TODIM lead to A5 as the best alternative and A7 being the worst alternative. It can also be concluded that A4 ranks as the 7th alternative and that A2 ranks as the 10th alternative. The analysis by THOR allowed classifying the alternatives according to clusters of dominance, leading to: A5 dom (A14, A11, A13, A1, A5) dom A4 dom (A8, A3) dom A2 dom (A6, A10, A12, A9) dom A7, where dom stands for the dominance relation. By applying the Rough Set Theory modulus of THOR (Gomes *et al*., 2008) it can be concluded that all criteria are relevant to the problem and therefore none of them can be discarded. Changing the weight of Criterion C7 from 1 to 15 would remove A5 from the condition of non-dominated.

In this study it was also possible to identify that three properties, A1, A13 and A15, fell into the same range established by the alternatives A4 and A11. From Table 10, it can be seen that the order of these three properties by using TODIM is: A13 $\succ$A1 $\succ$ A15. In this way, the rental values of these three properties could be the same. Alternatively, by giving a reference for the rental value of the property according to the ordering supplied by the method, the greatest value is attributed to A13 and the lowest value to A15. As shown in Table 8, the application of THOR to the same data leads to a full rank reversal, producing the following ordering for these three alternatives: A15 $\succ$ A1 $\succ$ A13.

The analysis of the alternatives using both THOR and TODIM led to ranks orders for extreme values. Those were in fact quite close and in agreement with the expectations of the experts. Through its formulation it became easier to resolve conflicts between criteria, as, sometimes, in order to achieve a good performance in a determined criterion of the analysis, it is necessary not to be concerned about performance in another (Belton and Stewart, 2002).

These results are particularly interesting when one takes into account that, although the weights used by both approaches are the same, the multicriteria methods embedded in THOR are essentially founded on the notion of outranking, present in methods of the French School of Multiple Criteria Analysis. The TODIM method, on the other hand, although based both on elements of the French and the American Schools, relies on the use of a multiattribute value function.

7 Conclusion

In the case of property evaluation, both approaches were capable of assisting professionals in the real estate market to evaluate the alternatives more clearly in relation to the criteria defined by the experts.

Thus, the analysis and the solution of the problem presented here, by means of either THOR or TODIM, reflected in their results the preferences of the decision agents. Those are indeed experts in the multiple dimensions of the problem analyzed. Consequently, it can be concluded that both methods constitutes efficient support for the evaluation of property. As new properties are included in the portfolio of a realtor, either one of the two methods must be run again taking into account the characteristics of these new properties. After the rank ordering is obtained for these new properties their suggested rental values will be determined with the help of Table 11.

Realtors concluded that applying either THOR or TODIM to the rental evaluation of residential properties can provide a considerable help to them. This is particularly true when one takes into account the extreme difficulties in assigning dollar values to all evaluation criteria. Given new evaluation scenarios, with a new set of evaluation criteria, however, new applications of the multicriteria analysis would have to be performed. Changes in the scenarios can lead to changes in estimated rental values even for properties whose rental values have previously been defined. For future studies efforts should also be focused on trying to quantify the monetary consequences associated to every criterion.

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