Automated Valuation Methods in Atypical Real Estate Markets Using the Mono-parametric Approach

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Abstract. The appraisal objectivity depends on the possibility to quickly and easily access to reliable real estate data in order to apply appropriate appraisal approaches. In order to ensure the objectivity of the real estate appraisals, in recent years Automated Valuation Methods (AVM) have been developed, integrating computerized real estate databases and programming languages. The Automated Valuation Methods proposed at international level usually recur to regression models, aimed to return appraisal equations based on reliable real estate databases. This approach is not applicable in some markets where lack of data does not allow the implementation of regression models. This paper proposes to implement a valuation automatic method in order to appraise properties located in atypical markets, structuring a procedural algorithm based on the mono-parametric approach and able to return punctual values related to the subject's specifics and to the market peculiarities in a very limited area. The paper proposes also the application of similarity degree coefficients in order to take into account the differences between the amounts of the real estate features, leading to the possibility to use the mono-parametric approach also when lack of data would not recommend it.

Keywords: Real estate market · Mono-parametric approach · Similarity degree · Automated Valuation Methods

1 Introduction

An Automated Valuation Method (AVM) is a calculation software with mathematical basis, able to produce market value appraisals based on the local real estate market, its parameters and the property characteristics, using information previously and separately

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collected and available in a computerized database. The distinguishing feature of an AVM is the use of mathematical models, so that AVM deeply differs from traditional valuation methods in which the appraiser physically inspects the property and relies mostly on experience and judgment to analyse real data and develop a market value appraisal.

The possibility offered by AVM compared to traditional valuation methods is to provide reliable values, in a fast, automatic, efficient, way, reducing costs, on condition that the database contains accurate and reliable data, that analysis is consistent with the appraisal theory accepted by international standards, that modelling is properly tested prior to application.

The application of such procedures is made possible by the presence of real estate comparison data previously collected in a computer database.

The reliability of the results produced by an AVM is obviously linked to the reliability of real estate data available in the support database, which must be continuously monitored and updated in order to verify its integrity.

If the application of automatic valuation methods is relatively simple in dynamics and transparent real estate markets, the specifications in static and viscous real estate markets, for which the simple data collection may be difficult if not impossible, is complex.

Internationally, AVM are generally set on multiple regression models, in order to prediction functions, valid throughout the study area. The lack of data obviously makes unenforceable deploying multiple regression models in atypical realities. In these contexts, it is considered more appropriate to provide procedural algorithms, that do not give back generally valid equations, but that are aimed to return punctual appraisals. In these situations, the AVM has to set in the computerized database tools able to select in the comparative mechanism few limited comparative properties, falling in a limited geographic area, resulting a very high level of detail that does not require extrapolation.

In this perspective, an interesting possibility is to use potentialities in the block programming tools, to implement flexible valuation procedures, in accordance with the guidelines provided by the international standards for automated valuations.

2 Literature Review

The idea of automating the sales comparison approach has appeared sporadically in the real estate literature over time and it has been used in some CAMA (Computer-Assisted Mass Appraisal) methods [1, 2]. Graaskamp and Robbins [3] developed an automated sales comparison system that they referred to as Market-Comp based on choosing small samples with very similar properties: an approach similar to ‘sales comparison adjustment grids’ used in conventional individual property appraisals. Detweiler and Radigan [4, 5] published an article describing their Computer-Assisted Real Estate Appraisal Sys-tem (CAREAS). Their work described a statistically derived dissimilarity index used to select comparables and a regression model to create adjustment factors. The use of sophisticated fitting techniques can account for different functional forms or, in some cases, the complete lack of functional relationships. Spline regressions, nonparametric regressions, autoregressive techniques and spatial heterogeneity modelling are some

examples [6–10]. Incorporating spatial information in pricing models through the use of direct spatial modelling with Cartesian coordinates [11], geostatistical models [12, 13], or response surfaces [14] has improved the precision of price estimates. Other studies [15–19] have focused on improving sample selection by delineating submarkets of homes in which the marginal price contributions of independent variables are more likely to be similar. Predicted residuals from nearby sales (spatial errors) have been used in two separate but related ways in the literature. Case et al. [20], in particular, developed a two-stage method in which errors from a single-stage ordinary least squares (OLS) model are used as predictors in the two stage model; conversely, Pace and Gilley [21, 22], among others, used a simultaneous auto-regressive (SAR) model to account for nearby residuals in a single stage model.

Bourassa, Hoesli, and Cantoni [23, 24] recently have dealt with uses of autoregressive models.

The application of the International Valuation Standards [25] have prompted research to investigate the possibility of applying the AVM even in really complex real estate markets [26], for different issues at stake, including best practices, real-life constrains, administrative procedures, software capabilities, expert competences, modelling frame-works, background theories and more [27–30], taking account that real estate analysis needs portals and databases in order to manage deficits of the non-spatial methods [31].

As far as we know, the mono-parametric approach has never been applied in AVM, moreover because the hypothesis of application in order to obtain certifiable values are very difficult to find, especially in atypical markets. That is why the mono-parametric-approach is mainly used in order to obtain indicative values on real estate prices or as a verification of the results obtained by other processes. The question is still under investigation, assuming that the operative real estate practice in atypical markets is quite far from the best one [32].

3 Methods

International Valuation Standards group the appraisal procedures in three categories (market approach, cost approach, income approach), which have different procedural articulation and baseline data, but all use a comparative method.

There is not a method better than the others, but it is possible to choose from time to time the one that best meets the case study's specific requirements, based on the property's characteristics and on the availability of comparative data. If the necessary real estate data are available, it is possible to build up an automatic procedure for each methodology, characterizing and differentiating just for the model's specification and variable coefficients calibration.

Calibration is the determination of the adjustments or of the coefficients used in the AVM through market analysis. If most of the existing AVM today uses statistical tools such as multiple linear regression and nonlinear regression to calibrate the model coefficients, it is also possible to use various calibration methods based on comparison functions and appraisal criteria.

With reference to this alternative and since the aim of the proposed project is the implementation of punctual appraisal procedures, rather than the identification of valuation equations generally valid in the context of the case study market, the calibration can be carried out through the use of economic postulates and the construction of the comparison functions, respecting the specificities of each implemented method.

3.1 Mono-parametric Approach

In wider terms, the mono-parametric approach can be summarized through the following five basic steps:

1. identification of comparable properties as much as possible similar to the subject, and surveying of their prices and amounts of the selected parameters;
2. construction of a known price scale based on the size of the parameter;
3. integration of subject in the corresponding scale step proportionate to the amount of the owned parameter;
4. determination of the subject's market value based on the position occupied in the scale;
5. any adjustment to the appraised value.

The determination of the most probable market value is based on the following

$$V_x : \pi_x = P_y : \pi_y, \tag{1}$$

where

- V_x è is the subject's market value (unknown);
- π_x and π_y are the amounts of the comparison parameter, respectively for the subject and the comparable (both known);
- P_y is the comparable's price (known).

From the abovementioned proportion, the elementary linear relationship used for determining the appraised value is deduced, if you have n comparables:

$$V_x = \frac{\sum_{i=1}^{n} P_i}{\sum_{i=1}^{n} \pi_i} \cdot \pi_x, \tag{2}$$

where $P_i = p_i \cdot \pi_i$ and pi represent the unitary average price.

In practice, the appraised value is determined by defining the average unit price obtained as an average of prices compared with the parameter amounts for several comparison properties.

The mono-parametric approach requires both analysis and synthesis abilities: analysis of the multiple characteristics and peculiarities of subject and comparables, looking for similarities; synthesis of the complexity and pluralities that contribute to the formation of the market value in a unique, represented by the comparison parameter. These operations require, of course, a remarkable ability to investigate, an adequate knowledge of the appraisal condition and objectives, as well as a significant experience of the specific market.

It is necessary to underline that the mono-parametric approach can be used in a scientific way and with reliable results only if comparables' features are identical to those of the subject, except for the comparison parameter. Otherwise, the appraisal would ignore the incidence of the properties' characteristics, leading to approximate appraisal results.

In atypical markets, the ideal conditions for the application of the mono-parametric approach conflict with the lack of the comparison data that, even when available, usually do not meet the application requirements (being equal to less than comparison parameter).

In the comparables selection, it would be possible to define some limits of acceptability in the divergence of the amounts of real estate features, designed to drive the exclusion/inclusion of comparables in the sample. But, even when it was possible to define a limit numerical index, with a scientifical and credible approach, the exclusion of comparables in atypical markets would substantially lead to the absence of the comparison data and, therefore, to the inapplicability of the procedure itself.

However, the possibility to apply the mono-parametric approach can be done using rationality measures [33] able to synthesize the differences in the amount of the real estate characteristics into similarity coefficients aimed to differently "weight" the comparables in relation to the different similarity degree.

3.2 Measure of the Similarity Degree

A similarity coefficient provides a measure of the degree of similarity between the comparables, giving values between 0 and 1, the first corresponding to observations with no common elements, the second relating to the surveys that perfectly meet the criterion used to measure the similarity.

A measure able to detect the similarity of individual properties in the real estate sample has its foundation in the "closeness" between the amounts of property characteristics: greater comparability means greater proximity of the amounts of the real estate characteristics; less comparability means amounts that are more distant. The measure of the "degree of similarity" of comparable properties may be expressed, therefore, as a function of the difference between the amounts of the *i*-th feature of the comparable and those of the subject.

This difference can be expressed in terms of absolute value in the following way:

$$gs_a^{j^*} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right| - \sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right|}{(m-1)\cdot\sum_{j=1}^{m}\sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right|} \tag{3}$$

where $gs_a^{j^*}$ is the indicator of the degree of similarity of a j* generic property of comparison and $\bar{x}_i$ is the average of the considered characteristic.

The difference between the amount of the i-th feature of the comparable and that corresponding to the subject can also be expressed in terms of square standardized distances, as follows:

$$gs_q^{j^*} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right|^2 - \sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right|^2}{(m-1)\cdot\sum_{j=1}^{m}\sum_{i=1}^{n}\left|\frac{x_{ij}-x_{i0}}{\bar{x}_i}\right|^2} \tag{4}$$

where $gs_q^{j^*}$ is the degree of similarity of a generic property of comparison j*.

3.3 Weighted Single Parameter Reconciliation

Resorting to the similarity coefficients, the reconciliation of the average prices related to the parameter can therefore be weighted using the (3) and (4) coefficients, as:

$$V_x = \frac{\sum_{i=1}^{n} P_j \cdot gs_a^{j^*}}{\sum_{i=1}^{n} \pi_i} \cdot \pi_x \tag{5}$$

$$V_x = \frac{\sum_{i=1}^{n} P_j \cdot gs_q^{j^*}}{\sum_{i=1}^{n} \pi_i} \cdot \pi_x \tag{6}$$

By removing the hypothesis of equal probability, the reconciliation made using the similarity coefficients can also be applied to comparable samples that do not meet the ideal conditions for the application of the mono-parametric approach. In this way, the mono-parametric approach can be applied in a scientific and rigorous manner even in atypical markets with limited data.

3.4 AVM Method's Specification

The implementation of the mono-parametric approach in an AVM can be done according to international valuation standards in operational terms [34], making automatic the selection of the comparable properties, the data processing, the coefficients determination and the market value appraisal:

1. definition of the subject and its detection on the map;
2. definition of the subject buffer within which to search for comparables;
3. identification of the comparative properties;
4. parameter measurements both for the subject and for the comparables;
5. similarity degree coefficients and average updated prices measurements (coefficient calibration);
6. review of the appraised value.

The approach could choose the surface characteristic as the comparison parameter. This choice would be the best one because the surface variables are proxies ones, and they are able to represent the incidence, albeit approximately, of the other characteristics in their unitary average price.

The subject property (spatially represented by an element of punctual geometry) would be placed on the map with a geocoding operation. A buffer (parametric entities) could be applied in order to investigate surroundings, in which to search the comparative properties, which would be detected by intersection of the buffer area and the layer relative to sales data.

Once the comparables have been selected, the procedure would switch to coefficients calibration, represented by the measurements of the surface's unitary average price and of the similarity degree coefficients, calculated in additional fields as a ratio of the weighted sum of the sales updated prices (to current date) and the sum of the corresponding surfaces:

$$p_x = \frac{\sum_{i=1}^{n} P_j \cdot gs_a^{j^*}}{\sum_{i=1}^{n} S_i} \cdot S_x \tag{7}$$

$$p_x = \frac{\sum_{i=1}^{n} P_j \cdot gs_q^{j^*}}{\sum_{i=1}^{n} S_i} \cdot S_x \tag{8}$$

The value would be then calculated by multiplying the surface average price for the subject's surface as:

$$V_x = p_x \cdot S_x \tag{9}$$

The procedure's reliability would be verified by applying to every real estate data in the database, considered as subject with unknown value, in order to calculate the ratio test, valuating the discrepancy between the appraised values and real sales price, and verifying that the obtained differences are contained within the limits reported in literature [33, 35].

The automatic procedure may be implemented using the programming tools available in the GIS software, such as the ArcGis Model Builder.

The advantage of this choice lies in the extreme flexibility of use of the implemented tool that, while working on a specific real estate database, is independent from it. The proposed procedure, not providing the generalization inherent in the analysis of the regressive models, can be used in real contexts different from the pilot one, provided that the real estate database has the same structure as the original one.

In Model Builder, the procedure would appear as a flow diagram that represents the algorithm and documents the process adopted in a transparent way.

4 Conclusion

This study aimed to assess the possibility of applying the automatic valuation methods in atypical real estate markets for which, given the lack of data, it is not possible to implement statistical models. In particular, it was thought the opportunity to set procedural algorithms in place of analysis models with the aim of returning punctual appraisals of the market value of individual properties, controlling the subjective

component which characterizes the traditional valuation in viscous real estate markets, through the use of computer software.

The proposed approach has been set on the application of the mono-parametric approach, appropriately weighting similarities and dissimilarities in the comparables using scientific coefficients in the reconciliation of the average updated prices.

This is a very interesting investigative option, because it allows an automated approach even in static and complex real estate markets.

The next step will be the test of the proposed approach in a real estate case study, for which the real estate database is already available, emphasizing that the proposed approach involves the implementation of an automatic procedure and not of an automatic model, so that the approach is independent from the used database and it can be applied in any case study.

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