CREATING AN INTERFERENCE MODEL OF THE CADASTRAL VALUE OF REAL ESTATE: ADVANTAGES FOR BUSINESS

CRIANDO UM MODELO DE INTERFERÊNCIA DO VALOR CADASTRAL DO IMÓVEL: VANTAGENS PARA OS NEGÓCIOS

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Resumo. Na formação de relações de mercado em países com economias em desenvolvimento, a avaliação cadastral de imóveis não é apenas uma forma de construir modelos matemáticos. Neste caso, um papel importante é atribuído às fontes de informação para a construção de modelos estatísticos confiáveis que levem em consideração as propriedades de interferência dos objetos imobiliários. A escolha do método de avaliação cadastral é confiada a especialistas altamente profissionais e com experiência relevante. Neste sentido, o objetivo desta investigação sobre os valores e as relações entre o valor de mercado e o valor cadastral do imóvel é determinar o seu impacto na forma de determinar a base tributável dos impostos prediais. Ao longo do estudo, as medidas propostas permitem o cálculo do valor cadastral, em primeiro lugar, para agilizar o atual sistema de formação de avaliações. Além disso, a utilização do fator de correção permitirá aos contribuintes estabelecer equidade na tributação dos impostos sobre a propriedade, uma vez que o valor cadastral é determinado por diferentes abordagens interferenciais, utilizando vários fatores de influência nos modelos. Método comparativo, método de custo, método de receita e combinação dos métodos propostos são utilizados. Face aos resultados, estas propostas são relevantes, especialmente nas actuais condições de influência da COVID-19 em todas as economias, bem como no clima de negócios das estruturas empresariais, uma vez que devido a factores macroeconómicos está a assumir uma tendência decrescente.

Palavras-chave: imobiliário, impostos sobre a propriedade, economia, atividade de avaliação

Abstract. When forming market relations in countries with developing economies, the cadastral valuation of real estate is not only a way to build mathematical models. In this case, an important role is assigned to sources of information for building reliable statistical models that take into account the interference properties of real estate objects. The choice of the method of cadastral valuation is assigned to highly professional specialists with relevant experience. In this regard, the purpose of this research on the values and relationships between the market and cadastral value of the property is to determine their impact on the way to determine the tax base for property taxes. Throughout the study, the proposed measures allow for the calculation of cadastral value, first, to streamline the current system of valuation formation. Besides, the use of the correction factor will allow payers to establish fairness in the taxation of property taxes, since the cadastral value is determined by different interferential approaches, using various influence factors in the models. Comparative method, Cost method, Revenue method, and Combination of the proposed methods are utilized. Given the results, these proposals are relevant, especially in the current conditions of COVID-19's influence on all economies, as well as on the business climate of business structures, since due to macroeconomic factors it is taking a downward trend.

Keywords: real estate, property taxes, economy, valuation activity

INTRODUCTION

The procedure for regulating the cadastral value of the real estate may be established under the direct influence of the state based on the state cadastral valuation. However, the market value may not always be used for cadastral value since, to a greater extent, economists, in particular Brelih et al. (2019), consider it sufficiently dynamic, which may be determined either by the buyer's subjective purchasing power or by the buyer's subjective estimates for a specific period. In turn, the market value is usually formed spontaneously based on the ratio of supply and demand, and the cadastral value to a greater extent is formed

mathematically. At the same time, the market value can be dynamic in the time process, i.e., it changes daily, while the cadastral value is more static and defined as a weighted average of market values with a correction factor for several periods (Korableva et al., 2020).

The purpose of determining the market value is usually to fix the price of a real estate purchase transaction. In turn, the purpose of determining the cadastral value is the need to calculate tax obligations and duties, as well as the calculation of the cost of renting state real estate. According to Gingrich et al. (2018), the cadastral price should always be less than the market price, and the cadastral value is more in line with the market value or even higher with rare exceptions (Han, 2020; Nikitin and Safonov, 2021; Chuvashlova et al., 2021; Kilinç and Tarman, 2022). However, the discrepancy between the objectives of the cadastral and market prices leads to court appeals with claims against both individuals and legal entities, as well as from state and local authorities.

According to research data (Chalkias et al., 2020), as a rule, the market value is determined only by the purchasing power of contractors, and the cadastral value is determined mainly based on the market value, taking into account the establishment of correction factors based on the characteristics of the object (Kuokkanen, 2020), as well as the appraiser's subjective opinion concerning the real estate object (Figure 1).
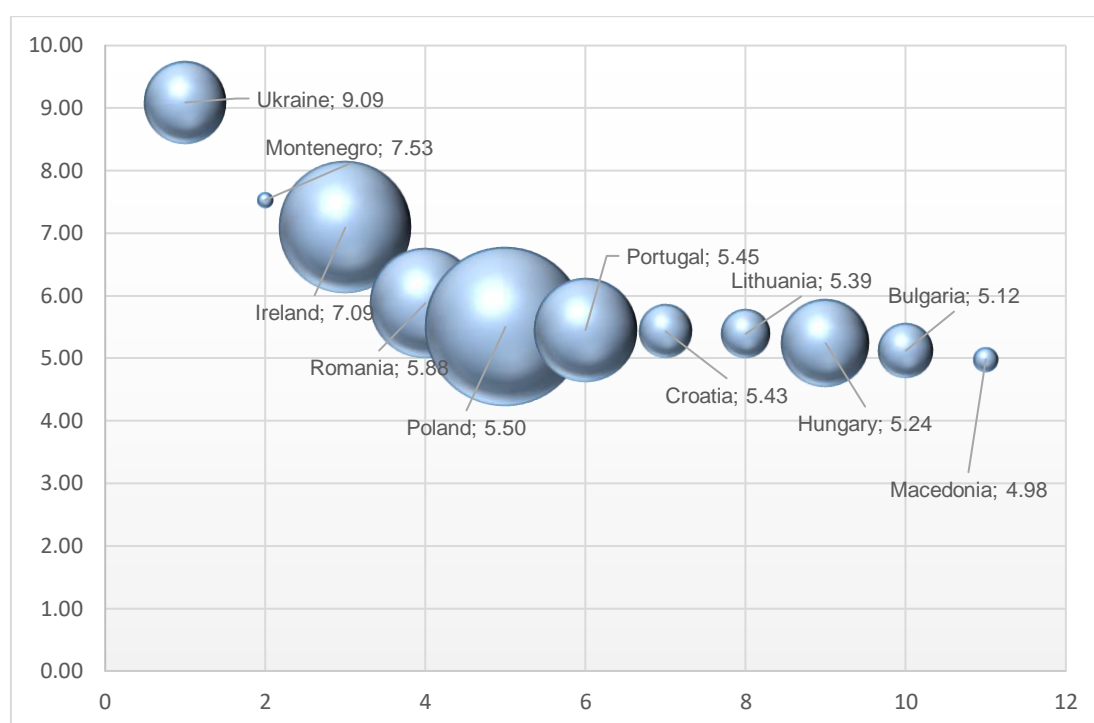

Figure 1. Ratio of changes in the market value of the real estate to GDP of individual EU countries as of April 1, 2020, % *(Compiled by the authors)*

However, the market value is usually subjective (Abramovich et al., 2017), and in turn, the cadastral value is according to (Nikoloudakis et al, 2020; Nguyen et al., 2020) more reasonable; however, the studies (Isaikina et al., 2021, Garcia, 2021) contain evidence of its subjectivity, as its use is based on the opinion of the appraiser, which determines the relevant characteristics of the object, laid in the construction of calculations models. Their values directly affect the source of their pre-values by the form, in particular, residential or non-residential property (Waychunas, 2020; Pogosyan, 2021a, b).

Thus, the purpose of studying the values and relationships between the market and cadastral value of the property is to determine their impact on the way to determine the tax base for property taxes. Thus, the research by Besley (2004) and Morozova et al. (2022) highlights several practical aspects that affect the value of determining the object of taxation of property tax and land tax, in particular, the transition from the inventory and residual value to the cadastral value when calculating the tax base, as well as the size and validity of the cadastral value carried out by public authorities.

METHODS

The concept of "cadastre" in historical terms dates back to the Roman Empire when the unit of accounting for the collection of tribute for land (caputigum) was approved, and the population census was introduced in the form of caputigum registrum. Over time, these words merged into one – capitastrum and subsequently, until today, formed the word "catastrum". In some countries, the cadastral value of the real estate is calculated based on the established regulations (Shugurov and Karpova, 2011), in particular, for Russia – the Federal law No. 135-FZ of July 29, 1998 "On Appraisal Activities in the Russian Federation" and Federal law No. 273-FZ of July 3, 2016 "On State Cadastral Valuation". There are separate Orders of the Ministry of Economic Development of Russia of May 12, 2017 No. 226 "On Approval of Methodical Instructions on the State Cadastral Evaluation" and the Ministry of Economic Development of Russia dated October 22, 2010 No. 508 "On Approval of Federal Valuation Standard "Determination of Cadastral Value". At the same time, the existing methods for determining the cadastral value can be established at the state level by budgetary institutions "State Institution Center for Cadastral Valuation", acting based on the Order of the Federal Service for State Registration, Cadastre and Cartography. At the same time, Federal Service for State Registration, Cadastre and Cartography is an executive authority responsible for registering and recording all real estate transactions, as well as for their cadastral valuation and cartography of real estate. The cadastral value is determined no more than every three years and no less than every five years, except for federal cities (two years minimum).

It should be noted that there are the following purposes of using the cadastral valuation of real estate, determined by the Federal Service for State Registration, Cadastre and Cartography:

1. Taxes – for property owners – land tax and property tax;
2. Taxes – for quitclaim deed for real estate;
3. Taxes – when applying the contract of sale if the price is lower than the cadastral value;
4. State duty – calculated for court cases, for inheritance, for rent of a budget real estate

The market value and the inventory value are usually not used for the abovementioned purposes (Lehoux et al., 2019). The market value is not used, since it is rapidly dynamic and is determined by the buyer's subjective purchasing power and the seller's subjective assessments. Although the market value should be close to the cadastral value, it is usually significantly lower.

In turn, the inventory value is not used because the estimation method is outdated, not objective, and is based on the cost of materials for the construction of the real estate, as well as taking into account the amount of accumulated depreciation. The inventory value is usually significantly lower than the cadastral value, and it is used in exceptional cases established in tax legislation.

The following methods can be used as the most widely used methods for calculating the cadastral value of real estate:

1. Mass valuation method
2. Individual valuation method

The current approaches used in the development of a model for estimating the cadastral value of the real estate and when using the mass valuation and individual valuation methods mainly apply:

1. Comparative method
2. Cost method
3. Revenue method
4. Combination of the proposed methods (Rubolino and Waldenström, 2020; Alayi et al., 2021).

Mathematical formulas consisting of characteristics (factors) of an object are used as models for determining cadastral value. Characteristics or factors can be combined by many relationships, forming an infinite number of models.

It should be noted that some methods for determining the characteristics of an object belong to specific approaches of specific models, some can be used in different approaches of different models, and some are created individually for a specific object. Thus, the factors that affect the valuation of real estate can be divided into the following types:

- Factors that can describe the macro-economic environment of the valuation object, such as the socio-economic state;

- Factors that describe the market of the valuation object, such as price level analysis, real estate lending;
- Factors that directly describe the valuation object, such as size and condition.

 It should be noted that the main methods of cadastral valuation are:

1. The mass valuation method. In this case, it is essential to pay attention to the process of determining the cadastral value in the mass valuation method, and zoning is carried out during evaluating. Roughly speaking, there is a division into price segments or territories where the cadastral valuation is carried out (Alayi et al., 2022). This happens only if there is sufficient information about the market value in the territories. Based on the zoning results (determining objects that are similar in characteristics and combining them), localities are typologized by characteristics, such as distance from transport centers and forecasts of economic growth (Volkova et al., 2020; Tarman and Kilinc, 2022).

However, individual sites that have special or unique conditions that differ significantly from the surrounding areas can also be selected as a price area; for example, the riverbank is included in this area. Further, it is possible to calculate the value of the average market price of a specific area per area unit, and this will be a way of stamping the cadastral price of objects based on their individually calculated value unit. As a rule, for correct calculation in the implementation of mass valuation, the following methods are used: method of statistical (regression) modeling – the method of a typical (reference) valuation object; modeling methods based on specific indicators of the cadastral value; method of indexing past results; method of direct capitalization; method of discounting cash flows, etc.

2. The individual valuation method. It is used in several cases, for example, when it is required to calculate the cost of a reference object, which will be described below. Another individual assessment may be required to increase the amount of information, in particular, about the market segment understudy, for subsequent statistical processing, and, accordingly, to find the cadastral value. Moreover, the last moment when an individual method can be applied, if there is no data about the market segment (which is very rare), therefore, it cannot be attributed to any price area, and the mass method cannot be used. The cost of the individual valuation method is higher, so it is used in practice by specialists in rare cases (Goryushkina et al., 2019).

RESULTS

A model for estimating cadastral value based on current legislation is a mathematical formula that shows the relationship between a dependent variable (cadastral value) and the values of independent variables (price factors) (Fig. 2).
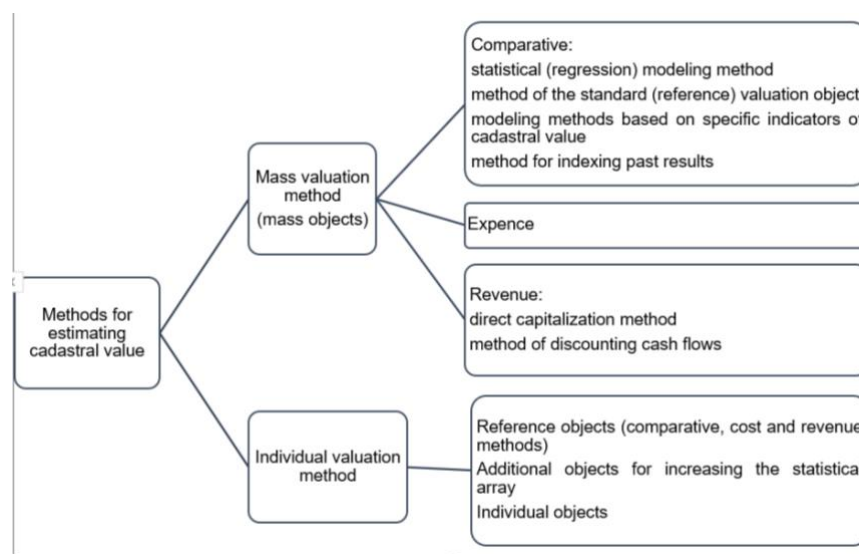

Figure 2. Generalized methods for estimating the cadastral value. *(Compiled by the authors)*

When estimating the cadastral value, a model with market characteristics (author's) is usually used based on market prices for the characteristics of a real estate object (characteristics of the real estate object, i.e., indicators related to the object and affecting the object price, in particular, the class of housing, the availability of appropriate infrastructure, characteristics of the land plot, etc.). At the same time, the comparative approach for the mass method applies market prices for the objects or their parts. With the cost-based approach of the mass method, these are the market prices of construction costs. With the revenue approach of the mass method, these are market prices for sale or rent. When using the method of individual assessment to market characteristics, it is essential to take into account the correction indicator for the "type of actual use of the object" (Jussibaliyeva et al., 2021). In particular, in the comparative approach of the individual method of the reference object, these are the market prices for the objects or their parts, as well as the added market price for the added characteristic, taking into account the intended use of the object, that is, for example, the cost of construction of the conducted gas and the factor value, established in respect of individual residential units.

In the cost approach of the individual method of the added object, these are the market price of construction costs and the cost contribution of businesses in the property (equity share capital of a filling station) and the factor on the "actual use of the object". In the revenue approach of the individual method of a single object, these are the market prices for sale or rent, as well as auxiliary objects in the form of movable property – the breakwater – the unfinished construction of a new hotel on the beach and the correction factor. It should be noted that in the comparative approach, the market value of similar objects is used as the basis for determining the cadastral value. This method is used if there are sufficient quantity and quality of information about the market value of similar objects. However, this approach is preferable for the current legislation on cadastral valuation.

In turn, the revenue method consists in the fact that the basis for determining the cadastral value is the projected cost of sale or the annual cost of the rent. In this case, the difference between the revenue approach by sales value and the comparative approach is based on the calculation model, taking into account the number and types of available indicators (characteristics) of the object used. The income approach for the amount of annual rent is individual. This approach is based on the principle of determining the value based on expected income without using information about the market value of transactions, but using accurate information about the market value of transactions and accurate information about the costs of market transactions, as well as using capitalization correction factors or discounting.

When using statistical (regression) modeling, it consists in fixing the price factors of a real estate object, determining their value and identifying their dependence using the following formula:

$$C_{VAL} = D(F_1, ..., F_n), \quad (1)$$

where C_{VAL} – cadastral value;
D – functional dependence;
F – price factors;
n – the number of price factors.

In this case, the price factors are selected by knowing the factors taken into account by the buyer when purchasing real estate (Figure 3).
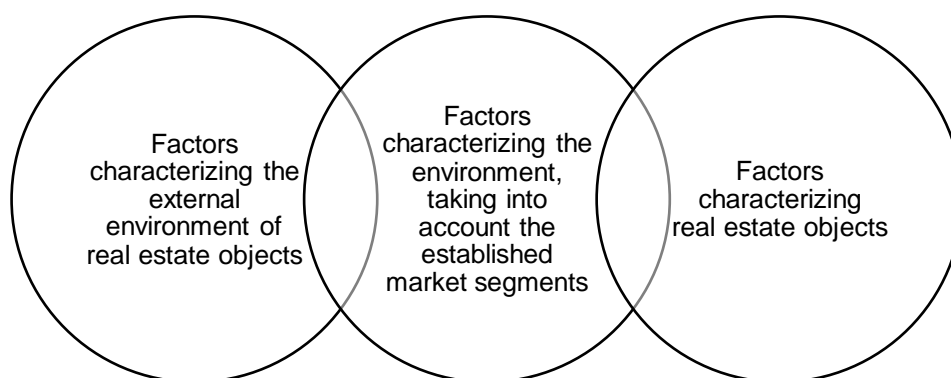

Figure 3. The main elements of price factors affecting the cadastral value. *(Compiled by the authors)*

It should be noted that the mandatory price factors are the object location and area, and the rest can be determined by one of the following methods.

The expert method – in this case, the price factors are determined by experts. When experts provide an opinion with a list of selected price factors, each of them must be justified.

The correlation and regression method – price factors must be systematized, and such a model includes factors that have a correlation value of 0.7–1.0, which shows the close relation of the factors to the cost, that is, how the presence of a concierge affects the cost of an apartment; if it is strongly affected, this factor will be included in the model. Next, a mathematical model is made (i.e., to choose a function, e.g. $y = ax + by$) which is used to calculate the value of all real estate, as long as the factors chosen by the appraisers influenced the price, to calculate the determination factor (significance) which takes the value of 0.3 or more, then the model can be used for evaluation. If in the course of calculations, it turns out that the search for a model of cadastral value estimation resulted in a few statistically significant models, then a more prominent one is chosen based on the determination factor R^2 (in the case of a linear regression model), and after that, the cadastral value is calculated by the most important models:

$$R^2 = 1 - \frac{ESS}{TSS}, \quad (2)$$

Where *ESS, TSS* are numerical characteristics that allow evaluating the reliability of the regression equation (function describing the studied dependence).

In turn, the method of a typical (reference) valuation object consists in fixing one price factor, for example, location (correction factor and variable) and another price factor – the cost of a typical object. It is assumed that such an object is the average price in the selected location, then the value of a typical object is determined, and the dependence of the location and cost is revealed using the following formula:

$$C_{VAL} = \mathrm{D}(C, L), \quad (3)$$

where D – functional dependency type;
C – typical object cost;
L – typical object location.

It should be noted that the methods used to determine price factors, as well as the types of functional dependencies used, are not disclosed in regulatory legal documents. However, the methods used to determine these elements must be justified, and each component is analyzed for compliance with the "solvability requirement". Thus, the method of a typical (reference) valuation object is applied to those real estate objects that should be evaluated in bulk (not individually). However, at the same time, they do not have enough market characteristics that could be translated into price factors with the attributed model factor. These objects are, for example, land plots and buildings in villages and so on – that is, objects for which there is no real estate market, and transactions are made individually. However, at the same time, the cadastral value for tax purposes must be determined according to current legislation, and individual assessment is not appropriate, because it is more expensive.

It is typical to use this method of modeling based on specific indicators of the cadastral value only in the absence of information about the exact location of the valuation object, and it consists in fixing the average cadastral value of similar objects per object area. However, mathematical dependencies and methods are not used to determine indicators. Appraisers use specific analogs of other objects and their known cadastral value using the ratio:

$$C_{VAL} = SCV_{avg} \cdot S, \quad (4)$$

where SCV_{avg} is the specific cadastral value, i.e., the actual cadastral value of a similar object;
S – object area.

A similar object with an already defined cadastral value is a real estate object that is similar in its appearance, its set of characteristics, and is located as close as possible (in the same district, region, etc. – it is not accurate and individual). This method is used for construction in progress, for items with unknown locations, or items with an unspecified purpose (Elveny et al., 2021).

In turn, the method of indexing past results consists in fixing the ratio of the cadastral value of the past calculation to the indexation factor. Mathematical dependencies and methods for determining

indicators are not used, specific data of the cadastral value of the previous calculation are used instead for specific objects, taking into account the determination of indexation factors that are not disclosed in the current legislation:

$$C_{VAL} = C_{VA1} \cdot F, \qquad (5)$$

where C_{VA1} is the cadastral value of the previous period;
F – indexation factor.

It should be noted that this method is applied only if it is not possible to use the above methods, and only applies to capital construction projects (not land plots) and only if there has been no change in characteristics since the previous valuation.

In this regard, the proposed method of cost substitution is to fix the amounts and differences in the cost of an object and its depreciation based on market prices for its new creation. Natural wear (depreciation) is the loss of suitability of a property or its components due to time (natural aging) or conditions of use, which leads to a drop in value:

$$C_{VAL} = C_{lp} + C_C - C_{dep}, \qquad (6)$$

where C_{lp} is the cost of the land plot;
C_C – the cost of construction, building, structure, etc., can be:
- replacement cost – the total cost of creating an object similar to the valuated object;
- reproduction cost – the sum of the cost of creating an object identical to the valuation object, using identical materials and technologies;

C_{dep} – cost of depreciation of the construction, building, or structure.

The proposed calculation formula (6) can be expanded with additional indicators that determine the quality of the model in addition to the characteristics of the object, for example, an indicator of the cost of improving the object can be added, the indicator of the ecological state of the area of ecological deterioration of the land plot can be subtracted.

When using the method of discounting cash flows (income method), which is more complex and detailed, assumes that future cash flows will differ from the present ones making it possible to evaluate the object in the case of unstable cash income from it. For example, if the revenue is seasonal, or a new facility is put into operation.

$$PV = \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} + \frac{R}{(1+i)^n} \qquad (7)$$

where R (reversion) is the residual value at the end of cash flow receipts;
i – discount rate (risk percentage for the investor, the rate may include compensation for risk, compensation for low liquidity, in some foreign countries, inflation, so the rate serves as the primary tool for reducing the property value);
C_t – cash receipts during the t period;
PV – cadastral property value;
n – ownership period.

DISCUSSION

When applying the methods used to generate cadastral values, indicators and characteristics for the corresponding real estate objects are used, which serve as the basis for the development of many different models. However, universal and most optimal characteristics can be represented functionally in the following way:
1. grouped by the types of real estate objects that are the basis for calculating the cadastral value (Akgul et al., 2018; Alayi et al., 2022).
2. use of additional factors, in particular, relative to the location of the real estate object (Volkova et al., 2020).

3. the degree of dependence between the type of a real estate object and the approaches used to compile the corresponding cadastral value valuation model (Akhmadeev, 2021).

However, the cadastral value of the estimated object can be determined mainly based on the conditional market value of similar model objects, which (conditional market value) is transferred to the entire set of the estimated objects.

The following main criteria can be used for the correct estimation: type of property, taking into account the influence of pricing factors and based on the property location (Creedy and Gemmell, 2020), the target use of the property (commercial, non-commercial, residential), options of elite and non-elite housing, finished objects or objects under construction (Avvakumova, 2020), refurbished or new, ready-to-use, relevant communications (Zvereva et al., 2020), and other applicable generic assessment of objects compiled based on special information documents.

It should be noted that the object location as a key price factor is the object of a separate special calculation:

1. using the location factor defined for the price area (Brovelli et al., 2016);
2. using the cost response surface to the location of valuation objects (Trnka et al., 2011);
3. using the distance values (distance ranges) from the objects of influence (price factors) of the valuation objects (Liu, 2022).

It is necessary to add economic, budgetary, and social assessment criteria to the qualitative technical assessment to improve the calculation of cadastral valuation, taking into account the purpose of its use (taxes, duties, and transactions with state real estate) (Ramadhani et al., 2018).

However, when developing the improvement method, the conditional assumption was used that existing methods of cadastral valuation are objective as they cannot be verified, they are complex, the details of their calculation are not published, counting is carried out automatically, and access control automation is not available except for directly involved individuals (Kevorkova et al., 2020), in particular, operating branches in the structure of the Federal Service for State Registration, Cadastre and Cartography.

Based on the results of the study, it can be concluded that when applying models for determining the cadastral value, the following proposed methods aimed at improving the calculation of the cadastral value are most important (Figure 4).
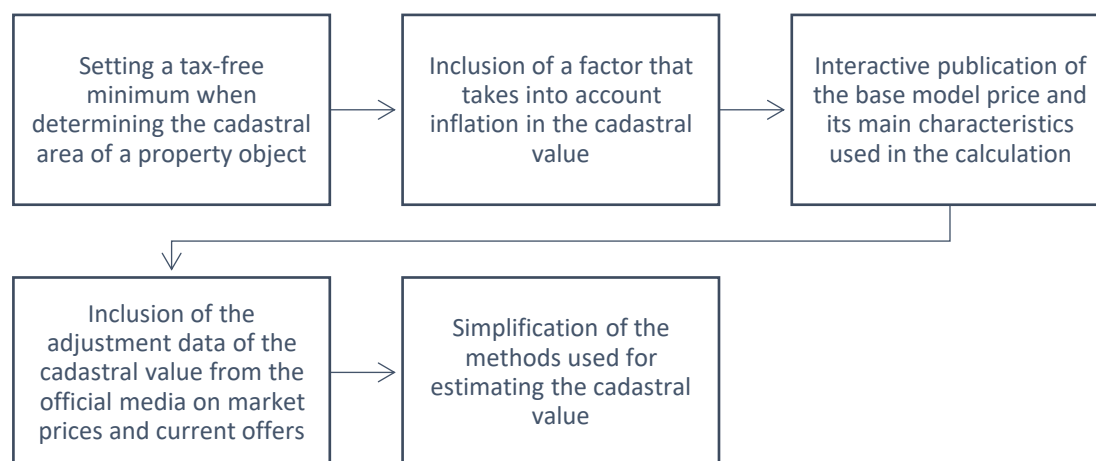
Figure 4. Algorithm of the proposed measures aimed at the applied preferential methods of determining the real estate cadastral value. *(Compiled by the authors)*

CONCLUSION

The proposed organizational measures for the formation of the cadastral value are primarily aimed at the regulation of the current system. Besides, through the use of correction factors, taxpayers will be able to establish fairness in the taxation of property taxes, since the cadastral value is determined by different models, using different factors, and the standard of living is declining especially in the current conditions of COVID-19 and constant economic crises.

However, the application of various approaches to the use of existing methods aimed at adjusting the cadastral value of the real estate is essential not only in terms of changes in the taxation object but also in regard to the payment of duties and other fees. The procedure for implementing state cadastral assessment and the ways to improve the cadastral value included in this mechanism are a necessary stage in the regulation of cadastral activities for the state and the economy.

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