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SALES COMPARISON APPROACH INDICATING HETEROGENEITY OF PARTICULAR TYPE OF REAL ESTATE AND CORRESPONDING VALUATION ACCURACY

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Abstract

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The article focuses on heterogeneity of goods, namely real estate and consequently deals with market valuation accuracy. The heterogeneity of real estate property is, in particular, that every unit is unique in terms of its construction, condition, financing and mainly location and thus assessing the value must necessarily be difficult. This research also indicates the rate of efficiency of markets across the types based on their level of variability.

The research is based on two databases consisting of various types of real estate with specific market parameters. These parameters determine the differences across the types and reveal heterogeneity. The first database has been set on valuations by sales comparison approach and the second one on data of real properties offered on the market. The methodology is based on univariate and multivariate statistics of key variables of those databases. The multivariate analysis is performed by Hotelling T^2 control chart and statistics with appropriate numerical characteristics. The results of both databases were joint by weights with regard to the dependence criterion of the variables. The final results indicate potential valuation accuracy across the types.

The main contribution of the research is that the evaluation was not only derived from the price deviation or distribution, but it also draws from causes of real property heterogeneity as a whole.

Keywords: sales comparison approach, heterogeneity, price adjustment, real estate, Hotelling T^2 control chart, valuation accuracy, offering

INTRODUCTION

The article focuses on heterogeneity of goods, namely real estate, and thereto related market valuation accuracy. Real estate property is heterogeneous, meaning that every unit is unique in terms of its construction, condition, financing and location; thus assessing the value is difficult (Jowsey, 2011).

The accuracy of valuations is shown to be partially dependent on local variable factors such as the extent of information, the variability of local cycles and the heterogeneity of the stock (Dunse *et al.*, 2010). This research also indicates the rate of efficiency of markets across the types methodologically based on their level of variability.

The key valuation approach used to fill the variables is named Sales Comparison Approach (further SCA). The valuations were utilized to explore heterogeneity of valuated properties and consequently to indicate the valuation accuracy.

The Sales Comparison Approach (also called market approach) is embedded in the International Valuation Standards (IVS) and also in the European Valuation Standards (EVS) as one of main approaches to receive a market value. Market value is intended by the following definition: "The estimated amount for which the property should exchange on the date of valuation between a willing buyer

I: *The possible decomposition of price adjustments*

LOCATION [RRE, CRE]	**CONDITION** [RRE, CRE]	**APPURTENANCE** [RRE, CRE]	**RESIDUALS** [RRE, CRE]
_GLOBAL LOCATION	_ACTUAL AGE	_LAND	
_SOCIAL EXCLUSION	_CONSTRUCTION	_GARAGE	
	_MAINTENANCE	_PARKPLACE	
_FREQUENCY [CRE]	_EQUIPMENT	_CABIN [RRE]	
_INFRASTRUCTURE	_PROD. FACILITIES [CRE]	_BARN [RRE]	
_MICROLOCATION [RRE]	_FN. OBSOLESCENCE	_OWN INFRASTRUCTURE [CRE]	
_PLACEMENT IN THE BUILDING [RRE]	_SIZE	_PAVED AREAS [CRE]	
		_UTILITIES	

Source: own

and a willing seller in an arm's length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently and without compulsion. "(IVSC, 2011; TEGOVA, 2012).

The most direct valuation approach is based on comparing the object to be valued with prices obtained for other similar objects (the more similar the better) in the same market to the valuation date. Each property is unique and as the comparables move away from the ideal of absolute similarity, they become less reliable. The reasons for dissimilarities are usually location, physical state, purpose and time (Shapiro, 2012).

The inherent practical implementation of the SCA valuation is based on the so-called Adjustment Grid Methods (Colwell *et al.*, 1983; Rattermann, 2007), which clearly allows to analyze and evaluate various factors of pairwise differences.

It is desirable to determine the size of potential dissimilarities received by individual valuating processes process. One property to be valued usually displays several dissimilarities, and most of them are frequently repeated in the valuations. In the context of the SCA the pertinent factor is price adjustments. Moreover, the price adjustments are closely related to price-setting factors. On the general scale, these factors reveal the dependence of the market price. Subsequently, some factors may have relatively low effect on pricing in comparison with others, e. g. flood risk (Cupal, 2015b).

The price adjustments have a specific tree structure and it is possible to decompose them. The Tab. I depicts the possible decomposition as a 2-level structure. The RRE and CRE abbreviations represent residential and commercial segments. Theoretically, the number of levels could be higher, but the price sensitivity and accuracy of determination would be very low.

If possible, the SCA uses mainly local markets. The SCA does not usually use more global price-setting factors, simply because the set of comparables must be reduced appropriately on closer observations. The SCA projected to market values sometimes contains 'crowding out effect' as substitution of one price-setting factor's power for the other one, while the market value remains unchanged. For example, higher amortization of a building can be compensated for by better location, quality and utility features (Cupal, 2015a).

A frequent question concerning the market value of a real estate evolves around price sources. Data often come from offering databases rather than sales databases. This difference is usually corrected by a particular valuation by a coefficient (Cupal, 2010). However, for the research, it is much more important to keep the data homogeneous in terms of data sources. Statistical methods could be ineffective for property valuation due to low transparency of the market and low confidentiality of transactions and it can be desirable to take uncertainty into consideration by using valuation methods and models (Meszek, 2013).

Besides the SCA data source, as an auxiliary source the research used variables measured during the offering of various types of property. This approach and database are described in more detail in the following chapters.

MATERIALS AND METHODS

The research is based on two databases consisting of various types of real estate with specific market parameters. These parameters determine the differences across the types and reveal heterogeneity. The results of both databases were joint by weights with regard to the dependence criterion of the variables. The final results indicate potential valuation accuracy across the types.

The first database uses 140 genuine market valuations by the Sales Comparison Approach (SCA)

II: *The Affiliation of Price Adjustments coefficient*

Coefficients / Index	Price adjustments
k_1	Location
k_2	Land
k_3	Physical state and equipment
k_4	Construction
k_5	Purpose
k_6	Garage
k_7	Size
k_8	Development potential
k_9	Utilities
k_{10}	Social conditions
k_{11}	Location in the building
k_{12}	Parking
k_{13}	Accessories
k_{14}	Possibility of terraces
k_{15}	Number of apartments
k_{16}	Land ownership
k_R	Residual component
I	Total adjustment index

Source: own

as mentioned in the previous chapter. The total number of all real estates (the comparables) in this database is 849. It can be entered as 140(849). The distribution according to the particular property type is as follows: family houses – 69 (426), lands – 30(187), apartments – 20(128), cabins – 6(31), restaurants – 2(11), warehouse and manufacturing grounds – 4(21), attic spaces – 2(9), apartment houses – 2(10), family houses (commercial purpose) – 3(15), garage – 1(7), commercial spaces – 1(4).

The second database of the research *"Price changing during the offering of real estate"* (Cupal, 2014) contains 500 observations. Although the purpose of this database, showing the heterogeneity of real estates, is auxiliary, the resulting values are entered. The previous research (Cupal, 2014) enabled to support this research to bring more significant as well as independent results.

Therefore, besides the real estate type, the first database is based on the key variable of the SCA: dissimilarity coefficient k_i, where i represents all types of price adjustments (see Tab. II). The total value of all price adjustments is expressed by index I. In these SCA valuations the following functional form was used to obtain I; $I = \Pi k_i$. For example, if there are not any dissimilarities, every coefficient k_i equals 1.00 and then $I = 1.00$ as a product of their multiplying. The method performance of various appraisers may differ. If the SCA is followed correctly, different appraisers using slightly different methods can and do arrive at final estimates of value that are very similar (Manaster, 1991). The SCA on the general level can be even appropriately described by linear algebra (Isakson, 2002). Specific conditions of real property (less accurate inputs) allow to use meaningfully a qualitative approach of performing that (Rhodes, 2014).

The dissimilarity coefficients k_i and index I as products of applied valuations performed represent variables (see Results) which enter another process, i.e. statistical analysis and evaluation. In this case they were submitted to multivariate analysis performed by Hotelling T^2 control chart to reveal the heterogeneity of particular type of property.

This multivariate method, the multivariate counterpart of Student's *t*, which also forms the basis for certain multivariate control charts, is based on Hotelling's T^2 distribution, which was introduced by Hotelling (Hotelling, 1947). When T^2 is generalized to p variables it becomes:

$$T^2 = n(\bar{\mathbb{X}} - \boldsymbol{\mu_0})\mathbb{S}^{-1}(\bar{\mathbb{X}} - \boldsymbol{\mu_0}),$$

with $\bar{\mathbb{X}} = (\bar{x}_1, \bar{x}_2, \dots \bar{x}_p)^T$ and $\boldsymbol{\mu_0} = (\mu_1^0, \mu_2^0, \dots \mu_p^0)^T$. $\mathbb{S}^{-1} \cdot \mathbb{S}^{-1}$ represents the inverse of the sample variance-covariance matrix $\mathbb{S}$ and n is the sample size upon which each $\bar{x}_i$ $(i = 1, 2, \dots, p)$ is based. The diagonal elements of are the variances and the off-diagonal elements are the covariances for the p variables (NIST/SEMATECH, 2013). The Hotelling T^2 is a distance chart, and the plotted points (T^2) indicate the distance of mean vectors (samples) from the center "point" (vector of centerline values, or means) in multivariate space. Moreover, the Hotelling T^2 chart can detect small "movements" or a drift in multivariate space that could not be picked up (as early) using simple univariate control charting (STATSOFT Inc., 2013).

One of the sets of the SCA variables named *DIST* was determined precisely according to the following procedure. The calculations are made on the basis of a spherical earth (ignoring ellipsoidal effects) – which is accurate enough for most purposes. The earth is very slightly ellipsoidal; using a spherical model gives errors typically up to 0.3 %. The co-ordinates entered the calculations as "deg-min-sec" format, e.g. 40°44′55″N, 73° 59′11″W. Haversine formula was used to calculate the great-circle distance between two points – the shortest distance over the earth's surface as the crow flies. Haversine formula is given as follows:

$$a = \sin^2(\Delta\varphi/2) + \cos\varphi_1 \cdot \cos\varphi_2 \cdot \sin^2(\Delta\lambda/2),$$

$$c = 2 \cdot \mathrm{atan2}(\sqrt{a}, \sqrt{(1-a)}),$$

$$d = R \cdot c,$$

where φ is latitude, λ is longitude, R is earth's radius; mean radius = 6,371 km (MOVABLE TYPE LTD, 2016).

Other variables, *AREA* and *PRICE* of the SCA, were easily available from individual valuation reports. The variables of the second database were obtained from *"Price changing during the offering of real estate"* research (Cupal, 2014) without changes or transformations.

The final statistics of both databases received from the selected multivariate method were joined by weights w_k derived from independence rate of variables. The independence rate of variables is expressed as nonparametric by Spearman rank correlation ρ (Spearman, 1906). The actual weights represent the inverted value of double sum of correlation matrix elements in the absolute value. Topologically, these are diagonal elements of one of the triangular matrices, since the correlation matrix is symmetric.

The research consists of two databases thus weights are determined as w_k for $k = 1$ and $k = 2$. Formally, the weights are expressed as follows:

$$w_k = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|\rho_{ij}\right|/2}, i \neq j,\ k \in \langle 1,2 \rangle,$$

where $\rho = 1 - \frac{6\sum_{x=1}^{N}(p_x - q_x)^2}{N(N^2-1)}$, p_x and q_x are ordinal values of both (k) variables (Spearman, 1906).

After outweighing we receive results for both databases according to the types. The subsequent analysis compares $\mathrm{Md}(T^2)_{\mathrm{SCA}}$ and $\mathrm{Md}(T^2)_{\mathrm{Offering}}$ and their common weight function $w\mathrm{Md}(T^2)$ determined as a weighted average. Some categories of the SCA did not match the second database, therefore, they had to be adapted and aggregated according to the purpose of their use.

The final table indicates valuation accuracy for all the types of property taking into account all relevant metrics mentioned in the article.

RESULTS

The first approach, the SCA, was required to calculate the key variable denoted as *I*. The calculation was performed for all the types of property which were valuated by the SCA. Primarily, index *I* was used to detect the overall dissimilarity of a particular type of property and consequently to indicate the heterogeneity of the property (the SCA framework). Tab. III. displays the results (see below).

The results of *I* index have a certain explanatory power, however, in order to conduct a more general and objective analysis, more key cross-sectional variables to evaluate the heterogeneity were required. The geographical distance between a pair of objects of a particular process of comparison denoted as *DIST* was another key variable. It was received as a product of the SCA valuations expressing physical availability of the nearest

III: *Results of total index I for a particular type of property*

Types of property	Index *I*
Lands	0.477
Family houses	0.335
Apartments	0.232
Restaurants	0.948
Commercial spaces	0.920
Apartment houses	0.452
Warehouse and manufacturing grounds	0.328
Cabins	0.326
Attic spaces	0.294
Family houses (commercial purpose)	0.288
Garages	0.008

Source: own

IV: *The list of key variables of SCA*

SCA Variables				
Denotation	**Name**	**Affiliation**	**Type**	**Description**
PRICE	Sales price of a comparable	SCA	ratio	Sales price of a particular comparable property at the time [CZK.10^6].
AREA	Relevant area for each type of property	SCA	ratio	Area used for valuations of a particular type of property; e.g. Net Floor Area, Built-up Area [m^2]
DIST	Geographical distance between a comparable and a unit to be valued	SCA	ratio	Geographical distance measured as the crow flies by the coordinates [km].
I	Total index of differences	SCA	ratio	It shows a total difference between one comparable unit and a corresponding unit to be valued as a multiplier [–].

Source: own

substitutes to the object to be valued (axiom of location). The computation of the *DIST* variable was described in more detail above.

Other variables are not SCA products and are independent of them. Nevertheless, they are key variables used for the computations. The first one denotes *PRICE* as a sales price of a particular comparable property and the second one, *AREA*, expresses an appropriate quantifier to the type of property. The Tab. IV displays all the variable with their types.

Relevant descriptive statistics were computed to indicate heterogeneity based on all the variables introduced above, specifically, the standard deviation as a one-dimensional characteristic for each variable; the expected value and median of Hotellings T^2 statistics as a multi-dimensional characteristics of all the variables. The rows express particular types of property.

Hotelling T^2 chart for individuals shows multidimensional variability of every single observation. It is evident that the observations with extremely high T^2 value come within the classes of property with a high probability of such occurrence. This is confirmed by the Fig. 1 as well as the table with numeric expression.

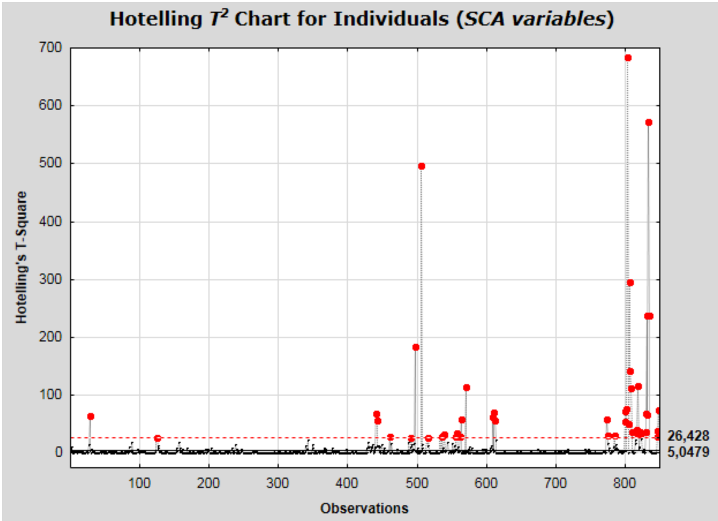
The Tab. VI contains detailed results with exact assignment to categories which are represented significantly unevenly in observations. However, such distribution of observations is very close to natural distribution of real estate according to the number of occurrences, transactions as well as valuations. The relative frequency of extreme values (where $t^2 \geq$ UCL) represents another significant indicator of heterogeneity. The relative frequency exceeding 15 % is marked in red. The results show that, unlike residential, commercial properties are mostly above the UCL. The difference between the two sets based on the occurrence of extremes is very significant.

The database of 500 real estate properties was taken over from the *"Price changing during the offering of real estate"* research. It also represents various types of property but categorises them slightly differently. Individual categories are represented much more equally according to the observations in comparison

V: *Selected descriptive statistics of relevant SCA variables for a particular type of property*

Type of property	σ(*PRICE*) [CZK.10^6]	σ(*AREA*) [m^2]	σ(*DIST*) [km]	σ(*I*)	E(T^2)	Md(T^2)
Family houses	2.629	74.82	12.02	0.33	2.53	1.39
Lands	4.845	21 256.73	17.27	0.48	11.72	2.49
Apartments	1.034	23.29	7.53	0.23	1.16	0.84
Cabins	0.441	17.31	8.78	0.33	2.05	1.47
Restaurants	1.654	372.13	17.21	0.95	12.92	5.28
Warehouse and manufacturing grounds	18.259	1201.12	4.41	0.33	49.24	4.36
Attic spaces	1.019	210.83	107.23	0.29	66.54	4.57
Apartment houses	7.150	330.06	0.71	0.45	34.66	28.72
Family houses (commercial purpose)	9.023	842.90	113.46	0.29	83.48	5.20
Garages	0.009	0.88	0.23	0.01	1.02	1.04
Commercial spaces	1.173	167.73	0.18	0.92	35.59	34.06

Source: own



1: *Hotelling T^2 chart for individuals (SCA database; 849 observations)*
Source: own

with the previous SCA. The cross-sectional variables are introduced and explained in the Tab. VII.

In fact, the final Hotelling T^2 chart for individuals displayed very similar results to the previous SCA. Nevertheless, as mentioned before, the categories are slightly different.

The detailed results of "Offering" provide a similar conclusion as the SCA results, i.e. extremes and their

VI: *Detailed results of Hotelling T^2 chart for individuals (SCA)*

Type of property	Observations	Center line	UCL [p = 0.00135]	Outside UCL	Relative Frequency
Family houses	1–426	5.0479	26.42767	2	0.47 %
Lands	427–613	5.0479	26.42767	17	9.09 %
Apartments	614–741	5.0479	26.42767	0	0.00 %
Cabins	742–772	5.0479	26.42767	0	0.00 %
Restaurants	773–783	5.0479	26.42767	2	18.18 %
Warehouse and manufacturing grounds	784–804	5.0479	26.42767	6	28.57 %
Attic spaces	805–813	5.0479	26.42767	4	44.44 %
Apartment houses	814–823	5.0479	26.42767	5	50.00 %
Family houses (commercial purpose)	824–838	5.0479	26.42767	6	40.00 %
Garages	839–845	5.0479	26.42767	0	0.00 %
Commercial spaces	846–849	5.0479	26.42767	3	75.00 %

Source: own

VII: *The list of key variables of the research "Price changing during the offering of real estate"*

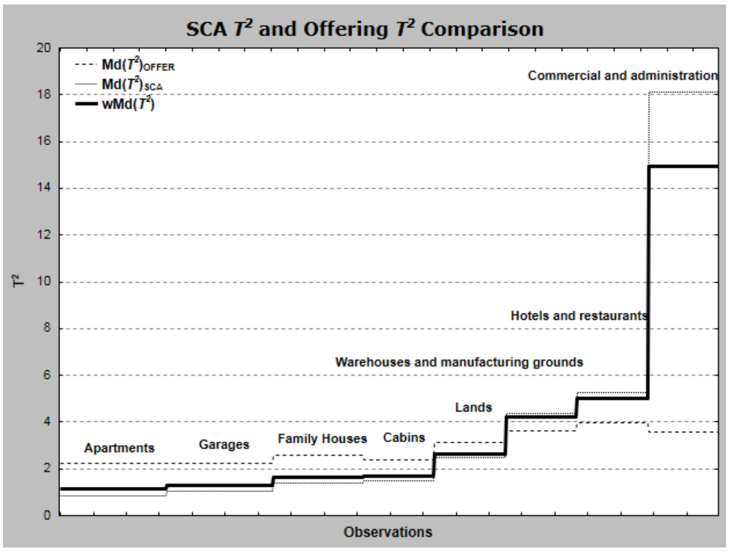
Offering Variables				
Denotation	**Name**	**Affiliation**	**Type**	**Description**
C_{PC}	Price changing coefficient	Offering	ratio	Ratio of sales price to offering price of a particular property [–].
Ln(T)	Offering time	Offering	ratio	Natural logarithm of the offering time. Time measured in days [day].
SALE	Making a sale	Offering	dichotomous	If a sale was made (value = 1) else (value = 0) [–].
OP	Offering price	Offering	ratio	Offering price of a particular type of property [CZK].
SP	Sales price	Offering	ratio	Sales price of a particular type of property [CZK].

Source: Cupal, 2014

VIII: *Detailed results of Hotelling T^2 chart for individuals ("Offering")*

Type of property	Observations	Center line	UCL [p = 0.00135]	Outside UCL	Relative Frequency
Garages	1–81	6.5555	29.171	0	0.00 %
Cabins	82–135	6.5555	29.171	0	0.00 %
Apartments	136–216	6.5555	29.171	0	0.00 %
Family houses	217–284	6.5555	29.171	0	0.00 %
Lands	285–338	6.5555	29.171	0	0.00 %
Commercial and administration	339–392	6.5555	29.171	5	9.26 %
Warehouses and manufacturing grounds	393–446	6.5555	29.171	4	7.41 %
Hotels and restaurants	447–500	6.5555	29.171	4	7.41 %

Source: Cupal, 2014



2: *SCA T^2 and offering T^2 comparison (SCA aggreg. database and offering database; 500 observations)*
Source: own

occurrence significantly vary between residential and commercial categories based on relative frequency. This database confirmed the difference even more markedly, it is still necessary to consider the disparity in the observations of the categories of both databases.

The graph comparing the SCA and "Offering" by their T^2 statistics (expressed as a median Md) displays slightly different results relative to one another, but relations across the types are comparable. The weight function (wMd(T^2)) is marked in bold. As "the SCA weight" was significantly higher than "the Offering weight", the course of weight function is significantly closer to the SCA function Md(T^2)$_{SCA}$.

DISCUSSION

The aim of the research was to examine possible application in the field of real estate valuation. Therefore, it does not draw solely from the economic theory. The results received should support the valuation process and the expected accuracy of the final market value.

A more general multivariate approach would require modeling of the joint probability of distribution of several variables. This would require the use of standard multivariate copulas or vine copulas as a way to construct multivariate distributions (see Nelsen, 2006; Montes-Iturrizaga *et al.*, 2016) and performing certain comparisons.

As mentioned above (Dunse, 2008), the characteristics of local markets are crucial for the valuation accuracy assessment. Based on the selected variables, the research showed certain relative rate of valuation accuracy. The Tab. IX captures the relevant statistics.

The results reveal a significant difference between residential and commercial segments. The values indicating the valuation accuracy by various statistics are divided into three ordinal scales for individual statistics; black (high accuracy), burgundy red (medium accuracy) and red (low accuracy). The first four types are black, so it is possible to estimate their value with high reliability. Lands, comprising all the types, are more heterogeneous. The most significant values of statistics proving valuation inaccuracy are those of various

IX: *Relevant statistics revealing rate of valuation accuracy*

Type of property	unidimensional statistics		multidimensional statistics		
	σ(PRICE)	σ(I)	E(T^2)	Md(T^2)	f_{EX}(T^2)
Apartments	1.034	0.23	1.57	1.14	0.00 %
Garages	0.009	0.01	1.46	1.31	0.00 %
Family houses	2.629	0.33	2.61	1.65	0.37 %
Cabins	0.441	0.33	2.32	1.66	0.00 %
Lands	4.845	0.48	10.01	2.63	7.10 %
Warehouses and manufacturing grounds	18.259	0.33	40.65	4.20	23.93 %
Hotels and restaurants	1.654	0.95	12.07	4.99	15.82 %
Commercial and administration	4.591	0.49	44.98	14.94	42.91 %

Source: own

commercial segments. This is mainly caused by their infrequent occurrence, the complexity of these types of property, a wide spread of prices for one purpose of property and low market information power generally.

The results appear to be rather unequal, which, however, was expected. Statistics were selected carefully to obtain an ample output. For example, the coefficient of variation could be applied to unidimensional statistics. Nevertheless, this would mean omitting the effect of absolute amount of a transaction. This is related to the availability of goods, substitution effect and stratification of demand. Property must be valuated as a whole in a unified monetary expression.

Achieved results are applicable, inter alia, for real estate valuation, where is very important to find out valuation accuracy. It means not only a point estimate of value, but also yield of such value. Basic option could be for example a standard deviation of prices, but results are not meaningful and stationary for a given segment. Multidimensional statistics enable better anchoring in key characteristics of property. Actually, the issue is an analogy of hedonic price models.

CONCLUSION

The issue of heterogeneity of real property and consequently valuation accuracy has significant implications in valuation theory and practise. The research helped to determine heterogeneity of various types of property using unidimensional and multidimensional statistics. The weight function enabled to use data of both databases adequately, considering the dependence criterion.

The main contribution of the research lies in the evaluation being derived not only by the price deviation or distribution, but also by the causes of real property heterogeneity as a whole. The transition to the pure valuation consequently consists in determining the function of the relative expression of the valuation accuracy as the weight function wMd(T^2) depicted on the second graph.

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