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Drivers behind the accuracy of self-reported home valuations: evidence from an emerging economy

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Received 8 February 2022
Revised 24 March 2022
18 May 2022
Accepted 30 June 2022

Abstract

Purpose – This paper aims to explore the drivers behind the accuracy of self-reported home valuations in the Warsaw (Poland) housing market.

Design/methodology/approach – In order to achieve the research goal, firstly, unique data on subjective residential property values estimated by their owners were compared with market-justified ones. The latter was calculated using geographically weighted regression, which allowed for taking into account spatially heterogeneous buyers' housing preferences. An ordered logit model was then used to identify the factors influencing the probability of the occurrence of bias towards over or undervaluation.

Findings – The results of the study revealed that, on average, homeowners overvalued their properties by only 1.94%, and the fraction of interviewees estimating their properties accurately ranges from 20% to 68%, depending on the size of the margin of error adopted. The drivers of the valuation bias variation were the physical, locational and neighbourhood attributes of the property as well as the personal characteristics of the respondents, for which their age and employment situation played a key role.

Originality/value – In contrast to previous studies, this is the first to examine drivers behind the accuracy of self-reported home valuations in a Central and Eastern Europe country. In addition, this work is the first to consider heterogeneous housing preferences when calculating objective property values.

Keywords Housing market, Geographically weighted regression, Valuation bias, Emerging economy, Endowment effect

Paper type Research paper

1. Introduction

Identifying the existence of the valuation bias in the housing market is important for several reasons. First, this phenomenon affects liquidity in the housing market, i.e. the larger the difference between subjective and objective home value, the fewer the transactions. Second, the valuation bias can affect banking services; in particular, as Huck *et al.* (2005) highlighted, excessive overvaluation of properties by their owners results in low demand for reverse mortgages. Third, the presence of the valuation bias can distort the examination of population wealth, which can lead to misguided housing policies. It is therefore critical to identify the extent of the accuracy of self-reported home valuations in the residential property market. In the scientific literature to date, research on the valuation bias in the context of housing has been done, for example, among the United States (US) (Kiel and Zabel, 1999), Mexico

JEL Classification — C21, D91, R31

Funding: The publication is financed by the National Science Centre of Poland (grant no. 2020/04/X/HS4/00458) and supported by the Foundation for Polish Science (FNP) under the START program.

(Gonzalez-Navarro and Quintana-Domeque, 2009), Israel (Tur-Sinai *et al.*, 2020), China (Gao and Liang, 2019), Australia (Melser, 2013), the Netherlands (van der Cruijsen *et al.*, 2014) and Philippines (Jimenez, 1982) residents. On this basis, the first research gap can be identified, i.e. the lack of similar surveys for any housing market in Central and Eastern Europe (CEE). It is important to fill this gap as the housing markets in the countries mentioned above are still in the process of formation after the communist period, and the knowledge on the accuracy of self-reported home valuations may significantly contribute to better public policies in the field of housing, mortgage, taxes and construction. Filling the identified scientific gap can only occur through new empirical analyses, not by referring to studies in other countries, because the owner's home valuation bias may be largely due to the endowment effect. The latter is an anomaly from standard economic theory and, in the framework of behavioural economics, can be defined as the situation when people demand more for the surrender of an object than they would be willing to pay (WTP) for it (Thaler, 1980; Kahneman *et al.*, 1991). In general, the endowment effect leads property owners to assign excessively high values to their flats, often well above what is justified by the market (Tur-Sinai *et al.*, 2020). However, the overvaluation bias might differ between societies because, as empirically confirmed by Maddux *et al.* (2010), there is considerable variation in the magnitude of the endowment effect across the globe. The same applies to loss aversion tendency (Wang *et al.*, 2017), which is the underlying cause of the endowment effect. All of this means that research on the accuracy of self-reported home valuations must be done independently for individual housing markets.

In view of the above premises, the first objective of this paper is to estimate the accuracy of self-reported home valuations in the Polish housing market, taking as an example the city of Warsaw, the capital of Poland. The research uses a unique database in the Polish circumstances concerning subjective property values estimated by their owners. The study's second objective is to identify the determinants explaining the variation in the valuation bias among the surveyed respondents. This study contributes to the current literature in several ways. First, it is the first analysis of the accuracy of home valuations determined by real estate owners in a CEE country and one of the few carried out for emerging markets. Second, in order to accurately estimate objective property values, a hedonic price model with both spatial effects (spatial heterogeneity and autocorrelation) is applied, which has not been used in this type of analysis before.

2. Literature review and hypothesis development

2.1 Magnitude of the owners' valuation bias identified in current housing studies

As already mentioned in the Introduction section, the accuracy of self-reported home valuations has been analysed in dozens of scientific studies. Dominating here are mainly works conducted for the real estate market in the US, on the basis of which it can be concluded that, on average, the owners of flats overestimate their value by about 5%. A very similar result can be observed in the context of studies performed for Australian cities. In particular, two such analysis have been produced so far, and the average valuation bias is +2%. These similarities between the Australian and American housing markets, maybe due to almost identical cultural peculiarities of societies in these countries (see Table 1), which affects the level of endowment effect. On the other hand, diametrically different results in terms of owners' valuation bias can be observed for China and Mexico. In particular, in these countries, the respondents overestimated the value of their residential properties by 60–100%, which could be due to the very low value of individualism for these societies. Therefore, it was decided to look more closely at the functional relationship between estimation error and particular dimensions of culture. In particular, one can notice that the higher the level of individualism, the lower the level of power distance and masculinity in a given society, the more accurate the predictions in terms of property value estimation by their owners (see Table 1). On this basis, the first research hypothesis was formulated as follows:

Table 1. The average values of valuation bias in the housing market surveyed and values of cultural dimensions

Author(s)	Average valuation bias	Country	Cultural dimension value Individualism	Power distance	Masculinity
Kish and Lansing (1954)	+4%	USA	91	40	62
Kain and Quigley (1972)	−2%	USA			
Robins and West (1977)	+5%	USA			
Ihlanfeldt and Martinez-Vazquez (1986)	+16%	USA			
Goodman and Ittner (1992)	+6%	USA			
DiPasquale and Somerville (1995)	+7%	USA			
Kiel and Zabel (1999)	+5%	USA			
Agarwal (2007)	+3%	USA			
Benítez-Silva *et al.* (2015)	+5–10%	USA			
Chan *et al.* (2016)	+3–4%	USA			
Haurin *et al.* (2018)	+4%	USA			
Average value	+5.4%	USA			
Melser (2013)	+3%	Australia	90	38	61
Windsor *et al.* (2015)	+1%	Australia			
Average value	+2%	Australia			
van der Cruijsen *et al.* (2014)	+13%	The Netherlands	80	38	14
Jimenez (1982)	+1%	Philippines	32	94	64
Gonzalez-Navarro and Quintana-Domeque (2009)	+60%	Mexico	30	81	69
Gao and Liang (2019)	+100%	China	20	80	66
Liang and Gao (2021)	+17%	China			
Average value	+58.5%	China			
Tur-Sinai *et al.* (2020)	+20%	Israel	54	13	47
Functional dependence†			$y = -0.31 \ln x + 1.44$ $R^2 = 0.61$	$y = 0.13 \ln x - 0.27$ $R^2 = 0.12$	$y = 0.11 \ln x - 0.20$ $R^2 = 0.06$
This study – prediction for Poland based on the identified above functional dependencies	+16% – based on the individualism dimension +28% – based on the power distance dimension +26% – based on the masculinity dimension	Poland	60	68	64

Note(s): † y denotes the level of valuation bias in a given country, x is a value of a given culture dimension (individualism or power distance or masculinity)

H1. Taking into account the values of the cultural dimensions of individualism, power distance and masculinity in the Polish housing market, it is predicted that owners on average overestimate the value of their properties by 16–28%.

2.2 Drivers of the valuation bias

Examining Table 1, one can find that the mean estimation error is positive in almost every study to date. As noted in the Introduction section, this situation may be due to the endowment effect. This fact was pointed out, among others, by Gao and Liang (2019), who described the results of their analysis and stated that "the self-reported home value doubles the real value. It falls into the framework of the Endowment Effect: people normally overvalue the product of their own". Therefore, in order to develop research hypotheses in terms of factors that may influence the level of home value misestimation, the theory behind the endowment effect can also be useful.

In the scientific literature to date, it has been shown that the magnitude of the endowment effect varies between different subjects (Jaeger *et al.*, 2020). In this context, it should be noted that residential properties are extremely heterogonous goods that differ from one another in the characteristics describing their physical parameters as well as their location and neighbourhood. Therefore, it is assumed that:

H2. The magnitude of the endowment effect in the housing market and thus the accuracy of self-reported home valuation depend on the property's physical characteristics and the specifics of its location and neighbourhood.

The above hypothesis has been positively verified, among others, by Tur-Sinai *et al.* (2020), who, while researching the housing market in Israel, noticed that owners of properties with air conditioning significantly overestimate their value in comparison to the rest of the respondents. This may result from the fact that the climate in this state is characterised by very high average air temperatures, and therefore having air conditioning may generate higher levels of loss aversion among owners. Also, a study by Ihlanfeldt and Martinez-Vazquez (1986) indicated that the overvaluation of properties by their owners increases with each additional bathroom and when having a carport. A similar relationship was also found by van der Cruijsen *et al.* (2014), who, when analysing the property market in the Netherlands, found that the endowment effect increases with each additional room and when a garden or patio is present. On the other hand, Kiel and Zabel (1999) concluded that valuation bias is not correlated with the property's physical characteristics, indicating the need for further research in this area.

In the context of analysing the physical characteristics of real estate and the scale of the occurrence of the endowment effect, attention should also be paid to the issue of luxury goods in the housing market. According to the theory of the endowment effect, its magnitude can be determined as the difference between the minimum value the seller is willing to accept (WTA) and the maximum value the buyer is WTP. In the case of luxury goods, an increase in the value of WTP can be expected due to the enjoyment of standing out (Romani *et al.*, 2012). When considering the above premise, another research hypothesis was defined, which is:

H3. The level of the overestimation bias decreases as the market value of the property increases.

Some studies to date have positively verified the above hypothesis. For example, we can cite the works done by Gonzalez-Navarro and Quintana-Domeque (2009), Goodman and Ittner (1992) and Tur-Sinai *et al.* (2020). On the other hand, Kain and Quigley's (1972) analysis shows a completely opposite relationship.

With regard to the attributes of neighbourhood and location, it is also possible to identify studies in which the authors have undertaken to test whether these types of attributes affect the error in real estate owners' estimation of property values. As an example, here is an analysis by

Kuzmenko and Timmins (2011), who, examining the US housing market, found that the tendency for owners to overestimate property values is significantly higher in Asian and Hispanic neighbourhoods. Also, research done in Mexico by Gonzalez-Navarro and Quintana-Domeque (2009) indicates a relationship between the real estate neighbourhood and the magnitude of the valuation bias. In this case, the authors identified that in new housing developments, the magnitude of this type of effect is much smaller, and property owners, compared to others, estimate the value of their dwellings much more accurately. In the context under consideration, it is also important to note the study of van der Cruijsen *et al.* (2014), where the researchers found that an estimation error decreases in urban areas, which can be explained by the possibility of anchoring on transactions in the immediate vicinity. The anchoring effect is one of the cognitive heuristics (Furnham and Boo, 2011). Tversky and Kahneman (1974) define that the anchoring effect involves making erroneous judgments as a result of being attached to some pre-presented value. In real estate transactions, this effect can lead to treating, for example, asking prices (Northcraft and Neale, 1987; Brzezicka, 2016; Cheung *et al.*, 2021; Sønstebø *et al.*, 2021) or previous property purchase prices (Leung and Tsang, 2013) as an anchor.

It should be noted that the strength of the endowment effect may be various for different individuals and therefore depend on the personal characteristics of the owners. One factor that is very likely to affect the endowment effect is age. It can be expected that with age, one can notice growing the self-possession link with the property (ownership account) as well as the increasing reluctance to get rid of it (loss aversion account). Therefore, it can be assumed that:

H4. As property owners age, they increasingly overvalue their property relative to what is justified by the market.

In the existing scientific literature on the housing market, the above hypothesis has not been resolved. Namely, there are both studies available that identify a positive correlation between age and the degree of property overvaluation (Agarwal, 2007; Ihlanfeldt and Martinez-Vazquez, 1986; Tur-Sinai *et al.*, 2020), as well as those where a negative relationship has been found (Goodman and Ittner, 1992; Melser, 2013; van der Cruijsen *et al.*, 2014).

Another important personal factor that may influence the scale of the occurrence of the endowment effect is the respondent's education. It may be assumed that people with higher education might rely more on various analyses and cold calculations and less on attachment to their property when valuing it. On this basis, another hypothesis can be formulated as follows:

H5. Individuals with higher education compared to others are characterised by a significantly smaller overestimation bias.

Previous research indicates a relatively unambiguous effect of the above variable on the valuation bias. Among others, Chan *et al.* (2016), Kain and Quigley (1972) and Kuzmenko and Timmins (2011) found that each additional year of education improves the accuracy of respondents' predictions about the value of their properties.

The next personal variable that can significantly shape the magnitude of the endowment effect is the income of the individual or the household as a whole. It should be noted that possessors with higher incomes are characterised by higher levels of loss aversion (Gaechter *et al.*, 2007), and therefore it can be postulated that:

H6. Higher household income increases the overestimation bias.

It should be noted that previous studies analysing the relationship defined in hypothesis H6 are not so clear. Among others, the work done by Chan *et al.* (2016) and Tur-Sinai *et al.* (2020) support the above hypothesis. On the other hand, an inverse relationship is reported in the analysis performed by Haurin *et al.* (2018).

Another important factor that may influence the magnitude of the endowment effect is a person's employment situation. It can be assumed that unemployed people have a higher degree of attachment to property compared to employed people, which is a direct result of more time spent in the dwelling. With regard to employed people, it is also possible to hypothesise the occurrence of differences in the strength of the endowment effect. Namely, as indicated by a study conducted by Gaechter *et al.* (2007), the level of loss aversion is lowest for entrepreneurs and managers, implying that these types of respondents are much less likely to overvalue their properties. Consequently, another research hypothesis is posed, which is:

H7. The unemployed, in comparison to those in active employment, overvalue their properties significantly more. Among the employed, the lowest overvaluation bias can be observed for entrepreneurs and respondents holding managerial positions.

The above hypothesis was confirmed, among others, in a study conducted by Kuzmenko and Timmins (2011) for the real estate market in the United States, where the unemployed significantly overestimated the value of their properties. On the other hand, for the same market, the opposite results were indicated by Agarwal (2007), according to whom the self-employed, compared to others, overestimated their dwellings much more.

The scale of the occurrence of the endowment effect may also be affected by the way the property was obtained. It can be assumed that people who bought property compared to those who got it for free will be more loss averse due to the fact that they had to spend a lot of capital to acquire it. On the other hand, such individuals may become anchored on the purchase price resulting in the disappearance of the endowment effect, especially if the purchase was relatively recent (Kain and Quigley, 1972). Consequently, a clear-cut hypothesis cannot be formulated here.

The intensity of the endowment effect may also differ for men and women, as pointed out in their study by Dommer and Swaminathan (2013). The authors noted that the variable strength of the possession-self link is higher for women than for men. On the other hand, van der Cruijsen *et al.* (2014) found that men are generally characterised by overconfidence which causes them to overestimate their possessions more than women. On the basis of both the above premises, also, in this case, it was not decided to set an unambiguous research hypothesis.

3. Methodology

3.1 Data and study area

The study area is the city of Warsaw, where the largest residential market in Poland operates. This analysis uses two databases, i.e. a survey questionnaire data (Tomal, 2021) and a state database on residential property transaction prices. The survey has been carried out using computer-assisted web interview (CAWI) technique between the 6th and 10th of November 2020 and covered randomly selected 1,000 residents of Warsaw who are owners or co-owners of a flat. Given that, according to valuation theory and practice, the best available measure of a property's value is the transaction price (Gaca, 2019) and following the latest research on the accuracy of self-reported home valuations (Gonzalez-Navarro and Quintana-Domeque, 2009; Melser, 2013; Windsor *et al.*, 2015; Chan *et al.*, 2016; Tur-Sinai *et al.*, 2020), interviewees were asked about the value of their dwelling using the question: "How much do you think you could currently receive if you sold the flat you own/co-own and in which you reside at the moment?". Moreover, in order to avoid anchoring respondents in offer prices presented on online portals, the time for answering the question was limited to three minutes. In addition, respondents were asked to provide characteristics of the dwelling for which they estimate the value in terms of its physical, locational and neighbourhood attributes. The survey questionnaire was also supplemented with data on the respondent's personal characteristics and information on how the dwelling was obtained. Table 2 presents basic descriptive

Variable	Mean	Standard deviation	Minimum	Maximum†
Self-reported value of a flat	685,778.44	372,120.11	190,000	3,125,000
Personal characteristics of a respondent				
Age	42.75	13.64	20	78
Household income (138 persons refused to reply)	9,835.72	6,469.54	3,000	50,000
Gender (1 – Male, 0 – Female)				477
Primary or secondary education (1 – Yes, 0 – No)				524
Higher education (1 – Yes, 0 – No)				476
Unemployed (1 – Yes, 0 – No)				66
Blue-collar worker (1 – Yes, 0 – No)				535
Manager or entrepreneur (1 – Yes, 0 – No)				399
The way of obtaining a flat				
Method of obtaining housing (1 – Purchase, 0 – Acquisition not requiring a financial contribution)				745
Purchase of a dwelling within the last two years (1 – Yes, 0 – No)				278
Dwelling and building characteristics – physical characteristics				
Number of rooms	2.25	1.40	1	10
Floor area	61.41	31.32	20	210
Storey on which the flat is situated	2.59	1.89	1	13
Age of the building	27.03	24.23	1	200
Number of storeys in the building	5.61	2.91	2	21
Availability of cellar or basement (1 – Yes, 0 – No)				729
Availability of garage or parking space (1 – Yes, 0 – No)				889
Flat in developer condition (1 – Yes, 0 – No)				112
Characteristics of the dwelling – locational features				
Distance in a straight line in meters to the city centre (Old Town)	4598.68	2448.82	300	12,000
Housing characteristics – neighbourhood features				
Distance in a straight line in metres to the nearest park	738.93	736.01	20	500
Distance in a straight line in metres to the nearest school	699.78	996.11	50	10,000
Distance in a straight line in metres to the nearest bus or tram stop	285.66	307.73	20	2500
Distance in a straight line in metres to the nearest supermarket	448.50	518.19	29	3000

Note(s): † For dummies variables, the value indicates the number of cases where a given variable takes the value 1

Table 2. Survey data – descriptive statistics

statistics for the collected data based on the survey questionnaire. It should be emphasised that thanks to such a large research sample compared to the entire city population, which amounts to 1,790,658 people as of 2019, this study can be considered representative in the context of not only the studied city but also other large urban areas in Poland and CEE.

As regards the second database, i.e. that concerning real estate prices observed on the residential market in Warsaw, only information on transactions carried out up to 3 months prior to the survey was used. This approach was aimed at minimising the impact of time on the research design. Finally, after eliminating outliers and incomplete observations, 7,198 transactions were obtained.

3.2 Investigating the valuation bias level

The following formula is used to identify the level of the valuation bias in the housing market under study:

$$VB_i = \frac{S_i - O_i}{O_i} \tag{1}$$

where S_i is the self-reported (subjective) value of the i-th property declared by its owner and O_i represents the estimated value of the same property based on observed transaction prices. In other words, O_i captures the value of the i-th residential property that is justified by the market. Therefore, the present study is based on revealed rather than stated preferences as in experimental studies. In order to determine O_i this analysis starts with the equation:

$$O_i = \exp(\ln \hat{v}_i) * \exp(\ln \mathit{floor\ area}_i) \tag{2}$$

where $\hat{v}_i$ is the estimated market value of the i-th flat and is calculated using the hedonic model accounting for the effects of spatial heterogeneity and autocorrelation:

$$\ln y_j = \beta_{j0}(u_j, v_j) + \beta_{j1}(u_j, v_j) \ln MP_j + \sum_{k=2}^{K} \beta_{jk}(u_j, v_j) \ln x_{jk} + \varepsilon_j \tag{3}$$

where y_j is the house price (PLN/m^2) of the j-th flat, (u_j, v_j) denotes the geographical coordinates of the j-th flat, ε_j is the error term, $\ln x_{jk}$ is the k-th ln regressor, $\ln MP$ is the ln mean price of flats in the district where the j-th flat is located. This variable is calculated as the ln mean price in the primary or secondary market, depending on which market the given transaction occurred. The incorporating of the $\ln MP$ regressor aims to account for the spatial autocorrelation of prices [1]. The set of regressors in Eq. (3) include the flat's characteristics described in Table 2, plus a variable concerning the dwelling's floor area squared to take into account the non-linear relationship between the property floor area and the price. Eq. (3) is a traditional geographically weighted regression (GWR) outlined by Brunsdon *et al.* (1996). GWR is a locally weighted regression that allows modelling the relationships between the dependent variable and predictors across space. Specifically, for each observation, a multiple regression model is estimated based on the subset of data, which is selected based on the distance from the regression point (fixed bandwidth) or based on the number of nearest neighbours (adaptive bandwidth). However, the latter is frequently used because the density of observations often varies across the study area (Fotheringham *et al.*, 2003). In addition, the chosen subset of data is weighted by a kernel function, whereby generally, observations that are closer to the regression point have a stronger impact. Fotheringham *et al.* (2003) recommend using the bi-square kernel function, as it produces a continuous weighting function up to a certain distance and zero weights for the remaining observations. The spatial weight from a bi-square kernel function can be written as follows:

$$w_{jp} = \left[1 - (a_{jp}/b)^2\right]^2 \ \mathit{when}\ a_{jp} < b;\ 0\ \mathit{otherwise} \tag{4}$$

where a_{jp} is the Euclidean distance between the regression point j and observation p, b is the optimal bandwidth. For the location of the regression point, the weight is equal to 1 and then decreases as the distance increases. Finally, when the distance between locations is greater than or equal to the assumed bandwidth, the weight is 0. Following Fotheringham *et al.* (2003)'s guidelines, a bi-square kernel function and an adaptive bandwidth were assumed in this study, and the latter was selected by cross-validation (CV). The latter procedure consists in minimising the following expression:

$$CV(b_r) = \sum_j \left(\ln y_j - \ln\widehat{y}_{(-j)}(b_r)\right)^2 \quad (5)$$

where b_r denotes the r-th bandwidth and $\ln\widehat{y}_{(-j)}$ refers to the fitted value from GWR with the j-th location being omitted during model calibration. Finally, b_r for which the CV score is the lowest serves as a b.

Considering the above, GWR allows generating the hedonic function varying in space, which is not possible in the traditional ordinary least squares (OLS) model that estimates one set of parameters for the whole study area. However, accounting for the spatial heterogeneity of the housing attributes' marginal prices is crucial for properly modelling the housing market. This is mainly due to the fact that submarkets with different housing preferences are present in the residential market (Watkins, 2001). One of the main alternatives to GWR is spatial filtering. However, Oshan and Fotheringham (2018) demonstrated that both techniques produce very similar results, with GWR being more intuitive and simpler to use in applied research. Consequently, GWR is very widely used for research to explore, model and predict variations in housing sales and rental prices (Hanink *et al.*, 2012; Yao and Stewart Fotheringham, 2016; McCord *et al.*, 2018; Tomal and Helbich, 2022) [2].

After calibrating the GWR model, the ln market (objective) value of 1 m^2 of each flat i is calculated as:

$$\ln\widehat{v}_{id} = \frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{j0}(u_j,v_j) + \left(\frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{j1}(u_j,v_j)\right)\ln MP_i + \sum_{k=2}^{K}\left(\frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{jk}(u_j,v_j)\right)\ln x_{ik} \quad (6)$$

where the index d refers to a Warsaw district and $d = 1 \ldots 16$, $\frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{j0}(u_j,v_j)$ is intended to capture the mean value of the estimated intercept in a district d from Eq. (3). The expressions $\frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{j1}(u_j,v_j)$ and $\frac{1}{J}\sum_{\substack{j=1 \\ d}}^{J}\widehat{\beta}_{jk}(u_j,v_j)$ represent the mean value of the calibrated parameters from Eq. (3) in a district d for the $\ln MP$ covariate and the regressor k respectively. In other words, Eq. (6) allows calculating the average parameter values generated by the model (3) for all districts in Warsaw. The ln unit market value of a flat i is then determined on this basis and depending on its location in a given district. Finally, Eq. (2) is used to estimate the market value for each dwelling i.

3.3 Exploring the valuation bias drivers

An ordered logit model is applied to identify the determinants of the accuracy of self-reported home valuations. It is important to determine the maximum valuation error so that the estimated home values by owners can still be considered acceptable and reflective of the property's true market value. However, there is no established magnitude of this type of error in the scientific literature. Therefore, the margin of error findings for property evaluations prepared by real estate appraisers can be used to determine it. It is assumed that the margin of error in extreme cases can amount to ±20%; however, as a rule, it is accepted at a level equal to ±10 to ±15% (Crosby *et al.*, 1998). Kucharska-Stasiak (2013), on the other hand, indicates that for residential properties, this margin should be less than ±5%. Therefore, this study is conducted for four situations when the margin of error is 5, 10, 15 and 20%, respectively.

Taking the above into account, depending on the value of the variable VB_i a new dependent variable (L) is constructed taking values 1, 2 or 3 as follows:

(1) if $VB_i \geq MOE_{VB}$ then $L = 3$

(2) if $MOE_{VB} > VB_i > -MOE_{VB}$ then $L = 2$

(3) if $VB_i \leq -MOE_{VB}$ then $L = 1$

where MOE_{VB} is the adopted margin of error, SD_{VB} denotes the standard deviation of VB_i. According to the above assignment, the significant valuation bias occurs only for observations for which the variable L takes the value 1 or 3. For a value of 3, it is an overestimation error, while for a value of 1, it is an underestimation error. In order to model the valuation accuracy, all the variables presented in Table 2 were taken as covariates in logit models.

4. Results and discussion

4.1 Estimates of valuation bias analysis

The starting point for determining the drivers of the valuation bias variation in the Warsaw residential market was estimating geographically weighted regression to explain real estate transaction prices. The estimated GWR model eliminated spatial autocorrelation of residuals ($Moran's\ I = -0.009,\ p = 0.22$) [3]. Further, the performance of the GWR model in terms of goodness-of-fit is high. In particular, the overall R^2 was 0.79 (see Table 3), which is a comparable or better result to other studies analysing the housing market in Warsaw (Bazyl, 2009; Trojanek *et al.*, 2018; Trojanek and Gluszak, 2018; Kopczewska and Ćwiakowski, 2021). Second, the local R^2 values (see Figure 1) also indicate that there are no locations for which price variability is explained to a small extent. Finally, the estimated Cook's distances indicate the absence of outlier observations that could significantly disturb the parameter estimates (see Figure 1). In particular, for all locations, the Cook's distance is significantly less than the accepted cut-off value of 1 (Cook and Weisberg, 1982).

Analysing the average values of the generated parameters, one should conclude that they are in line with the expectations (see Table 3). Interestingly, between the flat floor area and the dependent variable, a non-linear relationship has a U-shaped pattern. In particular, up to a certain point, each additional square metre of a flat decreases its unit price, then this dependence changes its form, i.e. the bigger the area, the higher the price for 1 m^2. The above phenomenon may be a consequence of the Veblen effect in the real estate market and, what is important, has also been confirmed in other studies analysing prices of flats in Warsaw (Trojanek *et al.*, 2018). In the case of the residential market, the Veblen effect is associated with the desire to own a luxury property, which increases the prestige of its owner (Brzezicka and Kobylińska, 2021). A large useable area characterises luxury real estate, and therefore a potential buyer of such a property, along with the increase in its size, does not expect a lower price per 1 m^2 but rather paradoxically is even WTP an additional amount for it. The results obtained are also in line with other studies regarding the neighbourhood and locational regressors. For example, the shorter the distance to the city centre, school and bus/tram stop, the higher the house price per 1 m^2, which has been confirmed by Trojanek and Gluszak (2018). Furthermore, a supermarket's vicinity is not considered a housing amenity, which may result from the noise produced by these buildings (Tomal, 2020). When considering the diagnostic tests conducted and the directions of influence of individual variables on house prices, it should be concluded that the estimated GWR model is a reliable predictive tool.

After calibrating the GWR model for the transactional housing prices, the real market value for each flat i was calculated, and further the corresponding valuation error. In Table 4,

Variable	Mean	STD	Minimum	Median	Maximum	SH	SC [%]
Intercept	4.012	12.704	−63.095	3.237	80.835	Yes	42.15
Ln floor area	−0.741	0.871	−4.561	−0.739	3.282	Yes	34.81
Ln floor area squared	0.085	0.109	−0.394	0.084	0.569	Yes	31.97
Ln building age	−0.066	0.057	−0.204	−0.064	0.123	Yes	60.33
Ln number of storeys in the building	−0.032	0.115	−0.446	−0.025	0.349	Yes	38.00
Ln storey number	0.032	0.032	−0.186	0.028	0.132	Yes	38.92
Ln rooms	−0.037	0.108	−0.465	−0.024	0.237	Yes	32.28
Primary market	−0.163	0.266	−1.515	−0.133	1.222	Yes	54.18
Ln MP	0.957	1.516	−6.662	0.968	8.867	Yes	84.46
Ln distance to city centre	−0.206	0.561	−2.266	−0.125	1.779	Yes	45.07
Ln distance to supermarket	0.005	0.042	−0.185	0.004	0.127	Yes	31.89
Ln distance to school	−0.005	0.052	−0.282	−0.005	0.177	Yes	25.13
Ln distance to park	0.009	0.042	−0.195	0.011	0.196	Yes	34.03
Ln distance to nearest bus/tram stop	−0.004	0.05	−0.185	0.002	0.137	Yes	27.86
Basement	0.004	0.041	−0.186	0.007	0.139	Yes	16.51
Garage	0.050	0.072	−0.397	0.058	0.453	Yes	52.65
R^2				0.792			
Bandwidth				204			
N				3597			

Note(s): STD means standard deviation. Due to the fact that the calibration of a GWR model is computationally demanding, 50% randomly selected observations were used for this purpose. SH means spatial heterogeneity. The latter was assessed based on Fotheringham *et al.* (2003) by comparing the interquartile value of the GWR local parameter estimates with twice the OLS standard error. A positive difference indicates a significant spatial variation in the local parameters. SC means percent of significant cases at 0.10 level

Table 3. Estimates of the GWR model

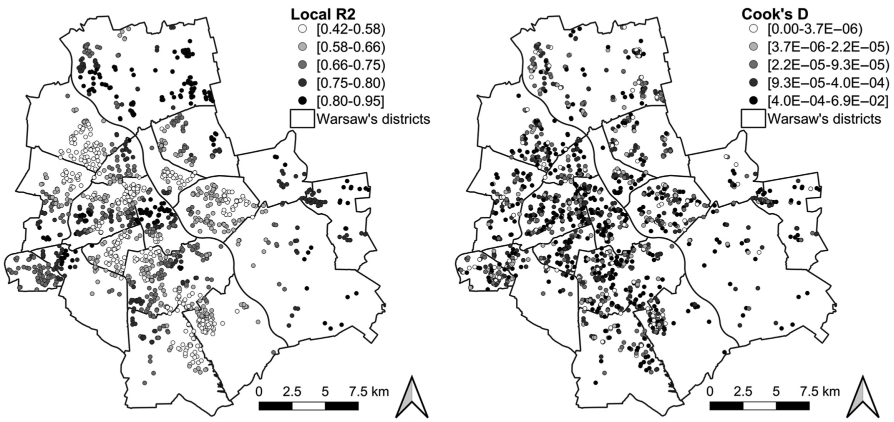

Figure 1. Local R2 values and Cook's distances of the estimated GWR model

one can see the estimates of this analysis. As we can see, on average, owners of properties in Warsaw overestimate their value by only 1.94%, which indicates very high accuracy of their valuations and contradicts the expectations created based on the specifics of the Polish society (hypothesis H1 is not confirmed). This result may be due to several reasons. First, the residential market in Warsaw is one of the most liquid markets in Poland, i.e. characterised by

Table 4.
Estimates of the valuation bias analysis

Value	Average valuation bias [PLN]	Average valuation bias [%]
Average†	−10,440.68	1.94%
Standard deviation	170,593.71	21.13%
Minimum	−1,187,724.31	−52.52%
Maximum	903,463.52	93.75%

Type of valuation bias	Margin of error ±5%	±10%	±15%	±20%
Significant overvaluation bias†	417 (42%)	334 (34%)	242 (24%)	175 (18%)
No valuation bias‡	204 (20%)	364 (36%)	540 (54%)	681 (68%)
Significant undervaluation bias*	379 (38%)	302 (30%)	218 (22%)	144 (14%)

Note(s): † Number of cases when $VB_i \geq MOE_{VB}$. ‡ Number of cases when $MOE_{VB} > VB_i > -MOE_{VB}$. * Number of cases when $VB_i \leq -MOE_{VB}$

a very high number of transactions. All this contributes to the fact that real estate purchase is becoming more and more routine, which lowers the level of information asymmetry on the market and leads to the reduction of the level of the endowment effect by weakening the loss aversion phenomenon (Kahneman, 1992). In addition, as many as 16% of the respondents surveyed expressed the view that they were not satisfied with their housing situation and, as a result, their attachment to housing as a thing may be significantly reduced (Tomal, 2021). In this context, it should also be stressed that the majority of the survey participants were relatively young people who very often grew up in a spirit of social mobility rather than attachment to one place.

It should also be noted that depending on the concept adopted for the size of the margin of error, between 20 and 68% of the sample is found to be free of valuation error for margins of error of respectively 5 and 20%. Furthermore, for these extremes of the margin of error, approximately 40 and 15% of the sample is characterised by an over or underestimation error. These values further confirm the high accuracy of valuations made by Warsaw property owners.

Next, it was checked whether there is spatial heterogeneity in the average valuation bias across the Warsaw districts. The results of this analysis are presented in Figure 2, which

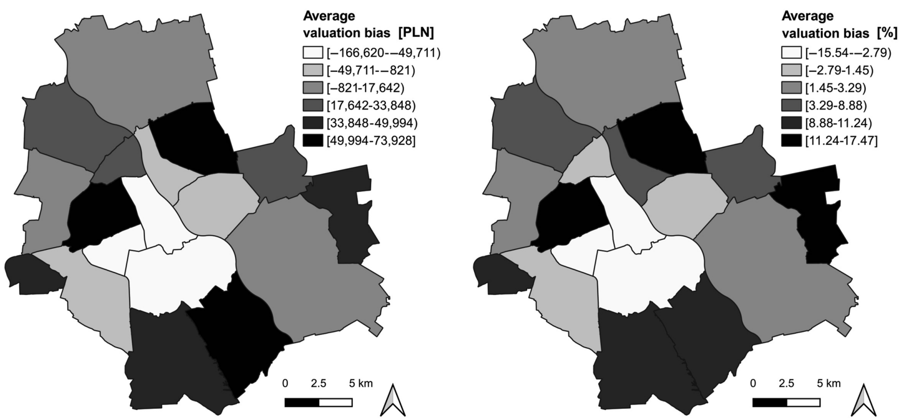

Figure 2.
Average values of the valuation bias across the Warsaw districs

shows that the valuation bias is absent in the city's central districts, which may be related to the presence in these areas of luxury properties for which the endowment effect is low. The obtained results also indicate a very strong localism of the Warsaw residential market, within which the formation of homogenous sub-markets can be observed, confirming the conclusions drawn by Kopczewska and Ćwiakowski (2021). On the other hand, the above estimates contradict those obtained by Melser (2013), who observed no change in the magnitude of owners' valuation bias; however, that study compared results between cities, not between districts within a single agglomeration.

4.2 What drives the accuracy of self-reported home valuations?

The next stage of the study was intended to explore the drivers of the valuation bias variation using the ordered logit method (see Table 5). Specifically, four ordered logit models were estimated separately for each error margin level. Analysing first the estimates of the average marginal effects for the physical, neighbourhood and locational characteristics of the property, it can be seen that in at least two models variables describing the age of the building, the floor area of the flat, the distance to the city centre and the nearest park and school turned out to be statistically significant. In relation to the first variable, it can be noted that as the age of the building increases, so does the probability of overvaluation of properties by their owners. This relationship is in line with expectations because the older the building, the longer the length of ownership of flats by individual residents, which in turn increases the level of estimated values due to the duration-of-current-ownership effect (Strahilevitz and Loewenstein, 1998). In terms of the ln floor area variable, the same kind of impact can be observed as for the regressor described above. Regarding the covariate on the distance to the city centre, the results obtained fully confirm the preliminary conclusions drawn in the previous sub-section. In the case of the last two regressors, the proximity of a park or a school increases the likelihood of property owners overvaluing their property. Taking all the above into account, hypothesis H2 can be positively verified. The result presented in Table 5 also confirms the previously identified relationship in the literature review section that the overvaluation bias is unlikely to happen for more expensive properties, which verifies hypothesis H3. It can also be concluded from the above that households living in low-value homes significantly overestimate their values. Tomal (2022) noted that this phenomenon might be a consequence of the high level of the endowment effect and a lack of access to hard information, and a desire to avoid embarrassment or social stigma among the poor.

When examining the estimates of the average marginal effects for variables describing the respondent's characteristics, it should be noted that a significant relationship exists only for the regressors relating to age and employment situation, and consequently, of hypotheses H4–H7, only hypothesis H4 was confirmed. Specifically, growth in the respondent's age increases the probability that the respondent's overvalue their properties, which can be justified by high level of the endowment effect among these people. Moreover, findings regarding being an entrepreneur are in total contradiction to hypothesis H7. Namely, the results obtained revealed that this type of person tends to significantly overvalue properties. This situation may be due to the fact that people in higher positions tend to make decisions (in this case concerning property valuation) based on behavioural factors such as overconfidence or overoptimism heuristic (Tomal, 2019). All this can lead to a significant overvaluation error.

The obtained results also indicate that the way in which the respondent acquired the dwelling does not influence the accuracy of respondents' home valuations. Therefore, it can be concluded with a high probability that the anchoring effect does not play a major role in the Warsaw housing market, at least in terms of anchoring in the purchase price of real estate.

Table 5.
Logit model estimates – drivers of the valuation bias variation

Covariate	Average marginal effects											
	Model 1: MOE = ±5%			Model 2: MOE = ±10%			Model 3: MOE = ±15%			Model 4: MOE = ±20%		
	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$
Personal characteristics of a respondent												
Ln age	−0.061†	−0.001	0.062†	−0.033	−0.002	0.036	−0.031	−0.004	0.035†	−0.019	0.005	0.025
Ln household Income	−0.004	−0.001	0.004	0.009	0.001	−0.009	0.021	0.002	−0.023	0.017	0.005	−0.023
Gender	0.033	0.001	−0.033	0.022	0.001	−0.002	−0.003	−0.001	0.003	−0.001	−0.001	0.001
Higher education[a]	−0.002	−0.001	0.001	−0.007	−0.001	0.008	−0.001	−0.001	0.001	−0.006	−0.001	0.007
Unemployed[b]	−0.052	−0.001	0.053	−0.005	−0.001	0.005	0.011	0.001	−0.013	0.013	0.003	−0.016
Manager or entrepreneur[b]	−0.029	0.001	0.030	−0.043*	−0.003*	0.047*	−0.027†	−0.003	0.031†	−0.003	−0.001	0.003
The way of obtaining a flat												
Purchase	0.023	0.001	−0.024	0.029	0.002	−0.031	0.016	0.002	−0.018	0.011	0.003	−0.015
Purchase within the last two years	−0.032	−0.001	0.032	−0.021	−0.001	0.022	0.001	0.001	−0.001	0.001	0.001	−0.001
Physical characteristics of a flat												
Ln rooms	0.043	0.001	−0.044	0.028	0.002	−0.031	0.010	0.001	−0.012	−0.008	−0.002	0.011
Ln floor area	−1.830**	−0.049	1.880**	−1.556**	−0.119*	1.675**	−1.279**	−0.167*	1.447**	−0.091**	−0.267**	1.182**
Ln storey number	−0.006	−0.001	0.006	−0.001	0.001	0.001	−0.004	−0.001	0.004	−0.007	−0.002	0.009
Ln building age	−0.023*	−0.001	0.024*	−0.027**	−0.002†	0.029**	−0.005	−0.001	0.005	0.004	0.001	−0.005
Ln number of storeys in the building	−0.001	−0.001	0.001	−0.008	−0.006	0.008	0.015	0.002	−0.017	0.001	0.001	−0.002
Basement	0.023	0.001	−0.023	0.019	0.001	−0.020	−0.001	−0.001	0.001	−0.017	−0.005	0.022
Garage	0.007	0.001	−0.007	0.011	0.001	−0.011	0.016	0.002	−0.018	0.014	0.004	−0.018
Locational and neighbourhood characteristics of a flat												
Ln distance to city centre	−0.100*	−0.002	0.103*	−0.079*	−0.006	0.085*	−0.071*	−0.009	0.081*	−0.051†	−0.014†	0.065†
Ln distance to nearest park	0.021*	0.001	−0.022*	0.021**	0.001†	−0.023**	0.012†	0.001	−0.014†	0.003	0.001	−0.004

(*continued*)

Table 5.

Covariate	Average marginal effects											
	Model 1: MOE = ±5%			Model 2: MOE = ±10%			Model 3: MOE = ±15%			Model 4: MOE = ±20%		
	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$	$L = 1$	$L = 2$	$L = 3$
Ln distance to nearest school	0.019*	0.001	−0.020*	0.007	0.001	−0.008	0.002	0.001	−0.002	0.012*	0.003[†]	−0.015*
Ln distance to nearest bus/tram stop	−0.012	−0.001	0.013	−0.011	−0.001	0.012	−0.006	−0.001	0.007	−0.002	−0.001	0.002
Ln distance to nearest supermarket	−0.001	−0.001	0.001	0.003	0.001	−0.003	0.005	0.001	−0.006	0.001	0.001	−0.002
Other characteristics												
Primary market	0.042	0.001	−0.044	−0.021	−0.001	0.023	−0.026	−0.003	0.029	−0.021	−0.006	0.028
Ln estimated market value	1.912**	0.052	−1.964**	1.634**	0.126*	−1.760**	1.371**	0.1799*	−1.551**	1.025**	0.299**	−1.325**
District fixed effects		YES			YES			YES			YES	
Observations		862			862			862			862	
Pseudo R^2		0.36			0.39			0.41			0.44	

Note(s): [a] baseline category is primary or secondary education. [b] baseline category is a blue-collar worker. ** one per cent level of significance. * five per cent level of significance. [†] ten per cent level of significance. The number of observations is lower because some respondents refused to answer regarding their income

5. Conclusions

Based on the study carried out, the following conclusions can be drawn: (1) on average, homeowners overvalue their properties by only 1.94% compared to what is justified by the market; (2) depending on the margin of error used, between 20 and 68% of the sample made an accurate forecast of the value of their property. In contrast, overestimation and underestimation errors occurred in both cases in about 15–40% of respondents; (3) there are significant differences in the valuation bias across the districts of the studied city. In the central areas of the city, respondents are most likely to undervalue their properties; (4) the level of the valuation bias is a function of the physical, neighbourhood, and locational characteristics of the dwelling, the level of its market value, and the respondent's personal characteristics.

This study has several limitations. First, this survey lacks information on the exact locations of the dwellings owned by the respondents, but only in the districts. This fact affects the accuracy of determining the market values of interviewees' properties. Second, as far as the database containing transactions of flats is concerned, no information was available on the technical condition and standard of flat, which implies an omitted variable bias. Future research should extend the area of analysis to housing markets characterised by a lower degree of liquidity, where a higher intensity of the endowment effect is expected to occur as a result of an increased level of loss aversion caused by the less routine nature of property sales transactions. In these types of markets, asymmetry of information will also be a far greater problem, which may result in an increased average estimation error. Finally, subsequent analyses should also pay attention to the problem of measuring self-reported home value. In particular, it should be checked whether there are differences in the results of the analysis depending on the orientation of the question to the transaction price of the property or its value.

This paper also has important policy implications. First of all, central or local authorities analysing the housing wealth in large Polish agglomerations may successfully use for this purpose not only transaction prices but also owners' self-reported home valuations due to very low average estimation error. Secondly, such high accuracy of owners' estimations can be a starting point for a discussion on the property appraisal profession, particularly the preparation of professional opinions for typical residential real estate.

Notes

1. There is no information on the exact locations of respondents' dwellings, and thus it is not possible to account for both spatial effects in a better way.
2. A detailed description of GWR is available in Fotheringham *et al.* (2003).
3. The residuals from the OLS model showed very strong spatial autocorrelation (*Moran's I* $= 0.303$; $p = 0.001$). The test was performed using a k-binary row-standardised spatial weight matrix ($k = 4$).

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