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The identification of spatial bubbles in a real estate market

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Abstract. There is great interest in identifying and modelling real estate market bubbles over time. However, the spatial dimension of those bubbles gets less attention. While building on the theory of real estate market equilibrium and formation of market bubbles, this research focuses on the spatial bubbles of the market value of apartments inside a city. This approach adds another dimension to the phenomena of real estate market bubbles. The scientific problem of this study is whether the spatial differentiation of real estate encourages the formation of spatial bubbles in real estate market. The object of research is the spatial bubbles in real estate market. The aim of research is to identify the impact of spatial bubbles on real estate market value. Because of the nature of real estate market, the supply and demand of real estate does not match, therefore real estate almost never reaches the equilibrium market value and bubbles appear. The main idea behind this research is that the supply and demand equilibrium model can be applied not only to the changes over time but also across space inside a city. The spatial bubbles appear because of unexplained variance. The empirical research focuses on unexplained variance across space of market value of homogeneous apartments in two major cities in Lithuania. The prominent variance is eliminated through careful selection of projects and control variables such as floor and size of an apartment, distance to civic points and location. Up to 39% of unexplained variance of apartment market value across space was found when looking at 3D diagrams of residualised apartment market value of the selected cities. The main reasons behind formation of those spatial bubbles should be addressed by further research for deeper understanding of the phenomenon of spatial bubble formation.

Keywords: real estate economics, variance of market value, spatial dependency, spatial bubbles, city scale

JEL Classification: R31, R32, D46

1. INTRODUCTION

There is great interest in identifying and modelling real estate market bubbles over time. However, the spatial dimension of those bubbles gets less attention. While building on the theory of real estate market equilibrium and formation of market bubbles, this research focuses on the spatial bubbles of the market value of apartments inside a city. Although the spatial dimension of real estate market value and bubbles has been acknowledged by Blank and Winnick (1953), Can (1990), Roehner (1999), Zietz et al (2008), Sun et al (2017), Glaeser (2017), it was in the empirical research that a hypothesis was raised that the spatial dependency can be attributed to unexplained variance created by neighbourhood urban design and individual building architectural design variables of selected projects inside a city. This approach adds another dimension to the phenomena of real estate market trends and bubbles.

The research focuses on the significance of the neighbourhood urban design and individual building architectural design variables (unexplained variance) to real estate market value in a quantitative manner. In broader context, the research tries to answer the question whether architectural quality of surroundings has influence on real estate market value. The scientific problem of this study is whether the spatial differentiation of real estate encourages the formation of spatial bubbles in real estate market. The object of research is spatial bubbles in real estate market. The aim of research is to identify the impact of spatial bubbles on real estate market value.

It is clear that some areas are more prone to bubbles (Roehner, 1999; Sun et al, 2017). The research looks at a city scale where aggregated market value can "hide" or "mutate" bubbles, therefore, the spatial bubble as a research object is introduced. The process of spatial bubbles identification appears to be opposite to house price index calculation. Instead of aggregating prices of various architectural objects, this research tries to deconstruct the aggregated values into the areas that contribute to aggregated market value more significantly and the areas that are lagging. The main focus of the research is to capture this phenomenon while looking at real estate market data as a 3D map rather than 2D graph.

While it is common to observe real estate market value volatility over time, the novelty of this study emerges from the research into the spatial dimension of apartment market value variance. This variance was observed at a city scale and its theoretical underpinnings are linked to architecture as a group of unexplained variables. This research looks at the phenomena of spatial bubbles in real estate market, building on the existing research about supply and demand mismatch and spatial dependency of real estate market. Up to 39% of apartment market value unexplained variance across space was found when looking at residualised apartment market value 3D diagrams of the selected cities. The limitations of the study include looking only at newly constructed partly finished apartments and their market value at a fixed moment in time.

This study consists of theoretical background (1) and research and discussion (2). The literature review and the theoretical framework for empirical research are presented in the first part. The economic intuition behind empirical research, selected context and variables, results and discussion are presented in the second part. The main findings with suggestions for further research are summarised in conclusions. Also, it is worth to notice that, although "market value" and "price" can have slightly different meanings, they are used as synonyms in this study.

2. THEORETICAL BACKGROUND

Real estate market value spatial dependency has been addressed in literature in many aspects. Blank and Winnick (1953) have seen submarkets in the housing market of United States. While submarkets can be based on various housing characteristics, a neighbourhood is one of them. Prices and values of real estate depend on many exogenous and endogenous elements, which should be taken into account in the market analysis, with a particular emphasis on detailed location (Cellmer & Trojanek, 2019; Trojanek et al., 2019). This has already started the discussion of spatial differentiation in the housing market. Can (1990) has been looking at neighbourhood dynamics of housing market of Columbus, Ohio MSA, United States, introducing a neighbourhood, which is spatially dependent, into housing price determination empirical research. The study from France by Roehner (1999) has shown the model that can describe various price trajectories in 20 Paris districts while looking at speculative trading, classic bubble formation argument, and price-supply inelasticity inside selected districts. These studies have shown that districts inside a city can have significant differences while determining real estate market value and this could be linked to local supply and demand models. Our research employs similar theoretical framework, however, the reasons behind changes in supply and demand remain unclear. There has been hints of an irrational nature of spatial differentiation as well.

The more recent study from China by Sun et al (2017) has been looking at spatial trends of housing market bubbles in China regions applying similar to previously described model at country scale. Although the scale and cultural context are different, we can see the same mechanism we try to introduce with this study at a city scale. Zietz et al (2008) has shown that various housing characteristics' price impact may vary across the distribution of homes from Orem/Provo, Utah area, United States. This suggests that the spatial differentiation could render traditional hedonic models inaccurate.

The study from Netherlands by Buitelaar and Shilder (2017) has seen the neo-traditional style as a determinant for demand, the formation of submarkets and the effects of externalities. Again, supply, demand, submarkets are the core determinants of market value. However, demand is biased by the buyer's desire for certain style, and, while real estate is fixed in place, the desire is for particular place at the same time. Glaeser (2017) has seen the benefits of real estate bubbles as extra building or urban development. This raises a discussion of reverse causality in the context of this research, whether an urban development causes bubbles or bubbles encourage an urban development.

According to the literature review, bubbles are mostly created by supply and demand mismatch. The next question is what the determinants of supply and demand themselves are. Of course, real estate fundamentals (Capozza et al, 2002; Agnello & Schuknecht, 2009; Glindro et al, 2011) have a significant impact on supply and demand, but this is true while talking about aggregated values of a country or whole cities where there is no differentiation between neighbourhoods and individual architectural objects (no submarkets). The question remains when looking at neighbourhoods and individual architectural objects at a city scale. We argue that the spatial bubbles, being unexplained, have origins in architectural surroundings. Shiller (2007; 2014), Tupėnaitė (2017), Navickas and Skripkiūnas (2020) has shown that we can look at other sciences, like architecture, to explain the unexplained part of price variance. We argue that there is a significant group of unexplained architectural variables in the first place that have influence to some places making them more desirable and creating supply and demand mismatch.

The theoretical background of bubble formation can be based on a simple supply and demand model. Because real estate market is slow it never actually reaches equilibrium market value, bounces up and down, therefore, creating upper and lower market bubbles (Pilinkienė et al., 2020) (figure 1). Because of the nature of real estate which is fixed in place, supply and demand of real estate is not global, but rather local. Therefore, the main idea behind this research is that you can apply this model either over time or across space. A hypothesis was raised that supply and demand are no less spatially dependent than time dependent.

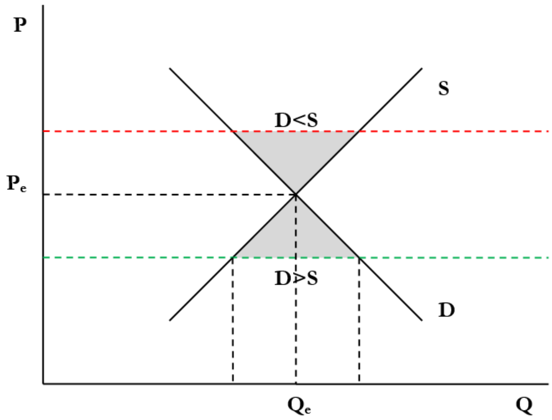

Figure 1. Real estate market equilibrium, upper and lower market bubbles

Source: Pilinkienė et al, 2020, adapted by authors.

A bubble appears when real estate market value deviation from real estate fundamentals increases irrationally according to rational expectations theory (Smith & Smith, 2006; Rosser, 1991; Cameron et al, 2006; Wiedemer et al., 2009; Baker, 2002; Garber, 1990; Glindro et al., 2011; Glaeser, 2008) or situation when we expect further change of market value in the same direction to continue according to irrational expectations theory (Kohn & Bryant, 2010; Case & Shiller, 2003; Shiller, 2000; 2002). A bubble cannot be explained by economic fundamentals, however, it should have a reason but the one that does not have origins in economics. This explains why bubble is seen as unexplained from economic point of view, however, it can have an explanation coming from other fields of science. In the context of this research, neighbourhood urban design and individual building architectural design variables are those unexplained reasons.

The economic intuition behind the spatial bubbles draws our attention towards the interrelationships between architecture and economics. The hypothesis was raised that observed unexplained variance across space, created by changes in supply and demand, can be attributed to architecture. The model applies to a city scale microenvironment. It helps to explain spatial bubbles inside a city, because local supply and demand mismatch inside a city creates local bubbles. This is quite intuitive when looking at real estate market value. The architectural variables, spreading across urban planning, urban design and individual building architectural design, appear when we search for reasons behind changes in demand. Shiller (2014) has suggested looking at other sciences while trying to explain market bubbles. Also, it is clear that certain architectural variables can increase or decrease supply, especially in the urban planning where actual supply of housing or other functions are being modelled. This evolves to the introduction of spatial bubbles.

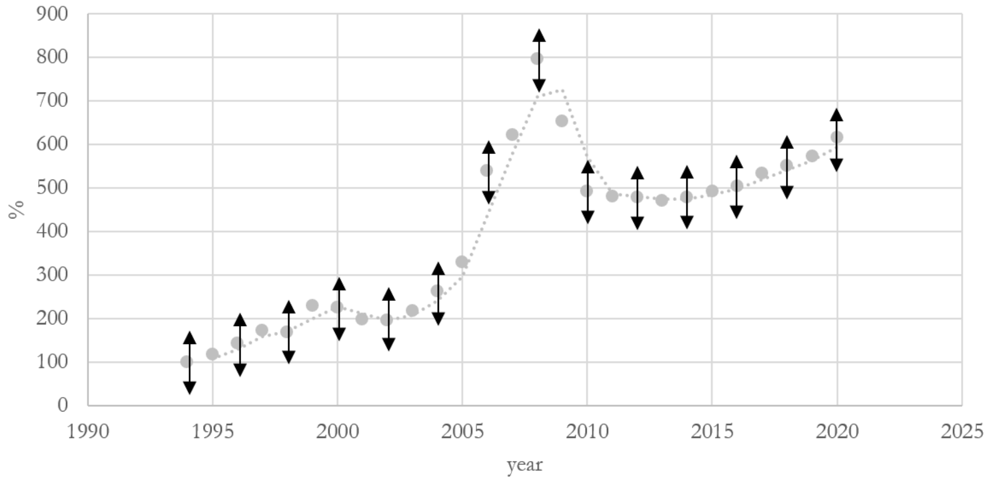

Figure 2. Ober-Haus Lithuanian apartments' price index (OBHI) (1994 = 100)
Source: Ober-Haus, 2020, adapted by authors.

We move forward with our theoretical framework building on hypothesis that variance across space is comparable to volatility over time. We have seen real estate bubbles over time as the significant phenomenon looking at aggregated values in time series of apartments' price indexes (figure 2), although the time series graph is "hiding" variance across space or spatial bubbles. House price indexes are good for macroenvironments, however, if we look at a city scale, aggregated values become inaccurate. Every point in the time series graph (figure 2) hides further variance across space. We can see the variance across space of selected apartments' market value in Vilnius at a fixed point in time (figure 3). Standard deviation of such variance – 543€, coefficient of variance – 22%. Only newly constructed partly finished apartments in urban environment were selected. Further research delves deeper into the spatial dependency of apartments' market value while aiming at removing the prominent variance.

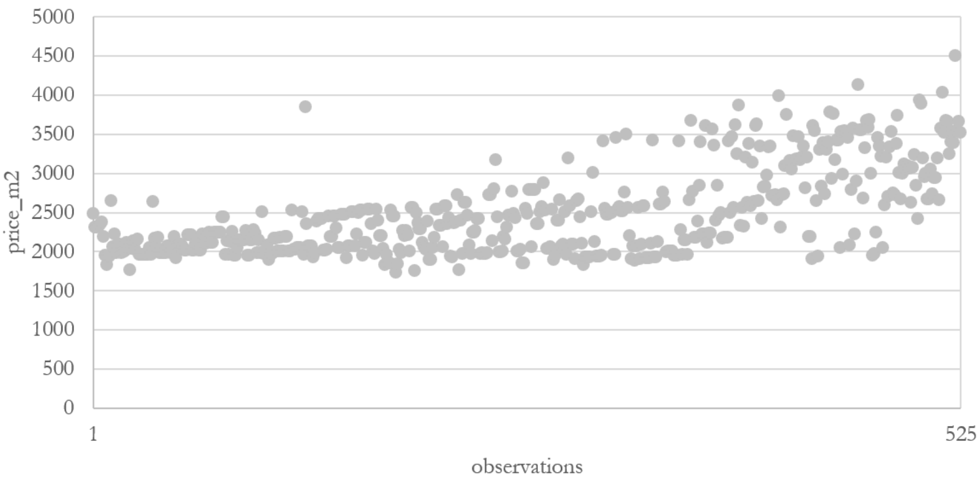

Figure 3. Variance across space of selected apartments' market value in Vilnius
Source: own evaluation.

Limitations of a theoretical framework were considered in the context of the complexity of various submarkets. This research aims to measure the unexplained variance across space of apartments' market value which may be seen as the spatial bubbles. We have already discussed that places with different supply and demand levels are a kind of submarkets. The segmentation based on buyers' properties (demand) or architectural objects' properties (supply) creates a kind of submarkets as well. While initially we were thinking about submarkets based on the position inside a city, submarkets can be based on buyers' income, type of housing or certain cultural aspects (Buitelaar & Shilder, 2017; Blank & Winnick, 1953) have observed examples of that). This concludes that supply, demand and resulting submarkets, expressed as various dimensions of variance across space (1), segments (2) and volatility over time (3), are the core groups of determinants of real estate market value. We are trying to prepare the theoretical background for introducing the 5-dimensional model of real estate market value analysis (figure 4) which would significantly improve the understanding of real estate market value determination process. This research starts with analysing the variance across space only.

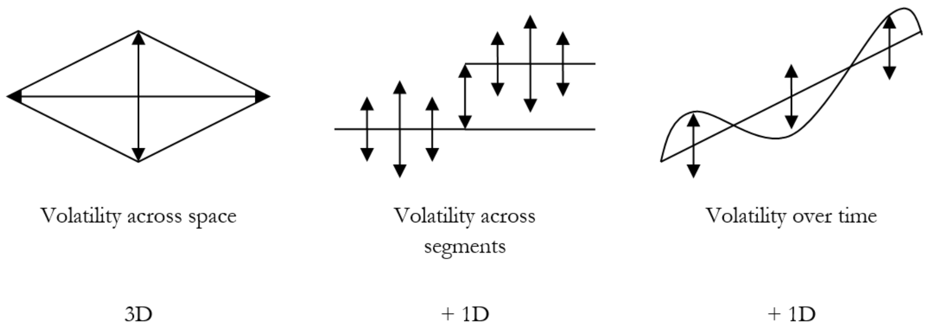

Figure 4. 5-dimensional model of real estate price analysis (3D space + segments + time)
Source: own evaluation.

3. RESEARCH AND DISCUSSION

Real estate, unlike many other consumer products, is very heterogeneous and one can argue that not a single object is identical to the other, therefore it is difficult to construct models as most economic models assume the homogeneity of the objects of interest. The first step of removing the heterogeneity was the selection of context for empirical research. The selected data for empirical research was narrowed down to the newly constructed, partly finished apartments in urban environment. This is a significant portion of real estate market and the one that gets great attention because housing is one of the biggest investments in consumer lifetime.

A regression analysis in various forms was used to identify the spatial bubbles. The empirical research was conducted in stages, but the main idea was to remove the prominent variance – trend, and work with the unexplained variance – residuals. In the end, our result was presented as the residualised apartments' market value 3D diagrams. Because of the unexplained nature, these residuals were treated as the spatial bubbles. The logarithmic regression was used for apartments' floor and size control variables, the power regression was used for apartments' location. These variables tend to impact the price not in a linear trend. The linear regression was used for apartments' neighbourhood civic points. The regression was the main method to residualise because we were interested in unexplained variance left. The empirical research was conducted in stages for better control and critical review over the intermediate findings. We were interested in removing the prominent variance and leaving only the unexplained variance. The economic intuition behind these methods goes in parallel with theory of real estate fundamentals and the unexplained nature of real estate market bubbles.

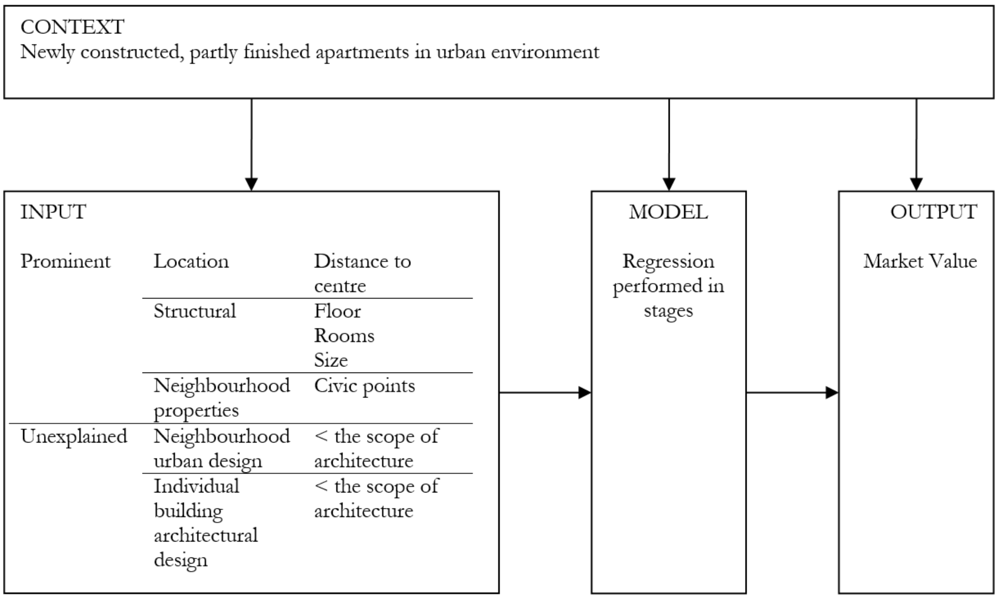

Figure 5. Apartments' market value variance across space research framework
Source: own evaluation.

The research framework is presented in figure 5. We were interested in the amount of unexplained variance that is left for neighbourhood urban design and individual building architectural design variables. A location can be hard to distinguish from a neighbourhood or architecture, because architecture creates neighbourhoods which are fixed in certain location. However, we tend to follow the concept that a location is treated as prominent variable, it defines the variance of position, which we want to eliminate, but not any architectural properties. Structural variables are inevitable to avoid when designing a building – we need differently sized apartments arranged in floors. A concept of neighbourhood is split between prominent variables (civic points including parks, squares, recreation facilities and other public spaces) and unexplained variables (urban design). Individual building architectural design variables are inseparable part of urban design but represent properties of individual objects.

To apply the theory of bubble formation to a city and its districts' microenvironment we need granular data. Four datasets were used for this research. The 1st and the 2nd datasets consist of new apartments of selected projects that have been published in real estate developers' websites for sale in Vilnius. Observations – 350-450. These datasets were used to get the coefficients for controls such as floor and size of apartment because we can select numerous identical apartments with just one parameter varying in these datasets. The 3rd and the 4th datasets consist of apartments that have been listed on the website for sale by brokers and individuals (NT žemėlapis, 2021). Observations – 576 (Vilnius) and 130 (Kaunas). The 3rd and the 4th datasets include spatially referenced apartments from two biggest cities in Lithuania – Vilnius and Kaunas. The descriptive statistics of selected datasets are presented in table 1.

Table 1

Descriptive statistics of selected datasets

	1st dataset floor/price_m2	**2nd dataset size/price_m2**	**3rd dataset Vilnius spatial**	**4th dataset Kaunas spatial**
Observations	350	450	576	130
rooms mean (min/max)	2,41 (1 – 4)	2,42 (1 – 4)	2,55 (1 – 5)	2,80 (1 – 6)
floor mean (min/max)	3,15 (1 – 9)	3,31 (1 – 8)	3,23 (1 – 16)	2,72 (1 – 9)
size_m2 mean (min/max)	51,31 (36,94 – 106,60)	52,22 (26,98 – 106,60)	60,48 (14,49 – 321,21)	62,98 (19,00 – 138,65)
balcony_m2 mean (min/max)	7,08 (1,58 – 34,34)	7,06 (1,58 – 34,34)	-	-
price mean (min/max)	124 270 (80 500 – 375 100)	129 433 (67 000 – 375 100)	158 771 (38 450 – 963 000)	110 041 (22 800 – 299 000)
price_m2 mean (min/max)	2 429 (1 729 – 3 992)	2 466 (1 729 – 4 133)	2 531 (1 149 – 9 032)	1 737 (1 022 – 2 794)
year mean (miun/max)	-	-	2020,95 (2018 - 2023)	2020,55 (2018 – 2022)
centre_km mean (min/max)	-	-	3,89 (0,50 – 13,54)	3,41 (0,41 – 6,94)
civic_num mean (min/max)	-	-	29,75 (0 – 57)	21,98 (1 – 36)

Source: own evaluation.

A 2-stage process was selected for empirical research. The 1st stage uses homogeneous apartments (the 1st and the 2nd datasets) to get coefficients of prominent structural variables. The 2nd stage uses those previously computed coefficients to residualise the broader dataset (the 3rd and the 4th datasets) also controlling for location and neighbourhood properties and identifying the spatial bubbles. In the end, we get the residualised spatial data free of prominent variables, therefore revealing the unexplained variance across space we were interested in. We look at that unexplained variance as spatial bubbles. The aim of this empirical research is to identify and measure the amount of this unexplained variance. This research employs reverse process compared to what CPI or HPI are doing while aggregating prices of heterogeneous architectural objects. We try to extract how the groups of individuals differentiate across space inside a selected dataset instead.

In the 1st stage only identical apartments with varying floor or size were selected (the 1st and the 2nd datasets). Identical apartments from the same project with the same layout and orientation one on top of each other were selected for the floor dependency research (figure 6). Apartments of different sizes from the same project and floor were selected for the size dependency research (figure 7). Apartments with significantly larger balconies or terraces were eliminated from the floor dependency research. Apartments with significantly different orientation in the same floor were eliminated from the size dependency research. This approach also involved careful inspection of the floor plans to prove the robustness of the results.

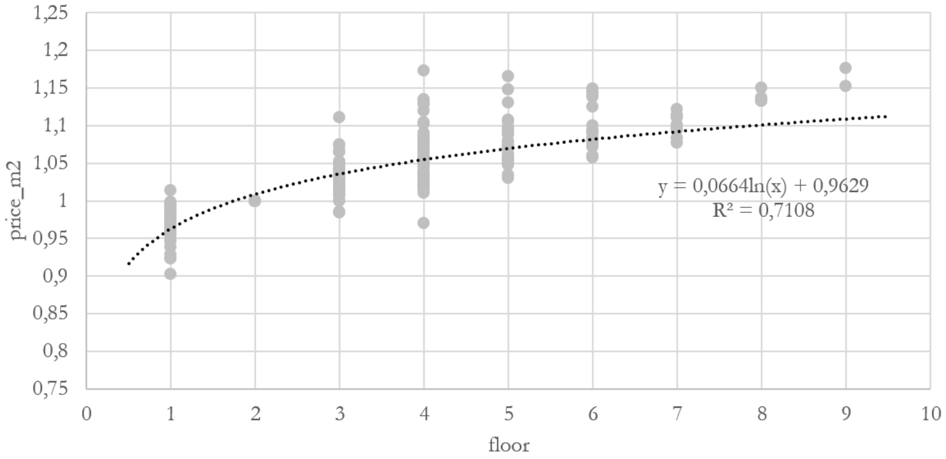

Figure 6. The relation between floor and price per sq. m of selected apartments in Vilnius
Source: own evaluation.

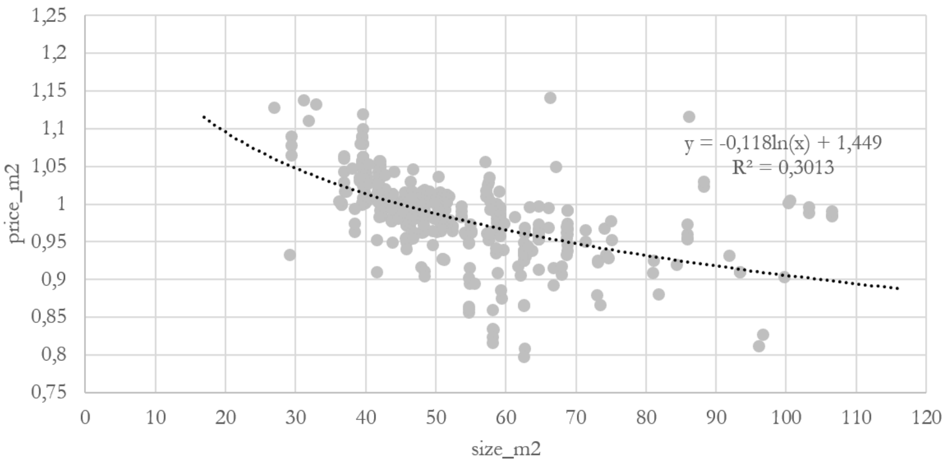

Figure 7. Relation between apartment size and price per sq. m of selected apartments in Vilnius
Source: own evaluation.

Every step was done to measure the relative price, therefore, market value of 2nd floor, 45 sq. m size apartment was selected as a reference point in the results. Diagrams show relative market value of apartments compared to the reference while changing the selected control variables such as floor or size (figures 6-7). The 2nd floor was selected as a reference because the 1st floor is highly dependent on neighbourhoods. While in most cases it trades with a discount compared to the 2nd floor, sometimes, especially further away from the city centre, it has a premium for possible terrace space or easy access, therefore, market value of the 1st floor apartments can be unstable and is not a good reference. Rooms' variable was dropped because it was found to be redundant and less accurate compared to size, therefore, size was used. In the 1st stage apartments were compared within their project, therefore there was no need to control for location, neighbourhood properties, neighbourhood urban design and individual building architectural design.

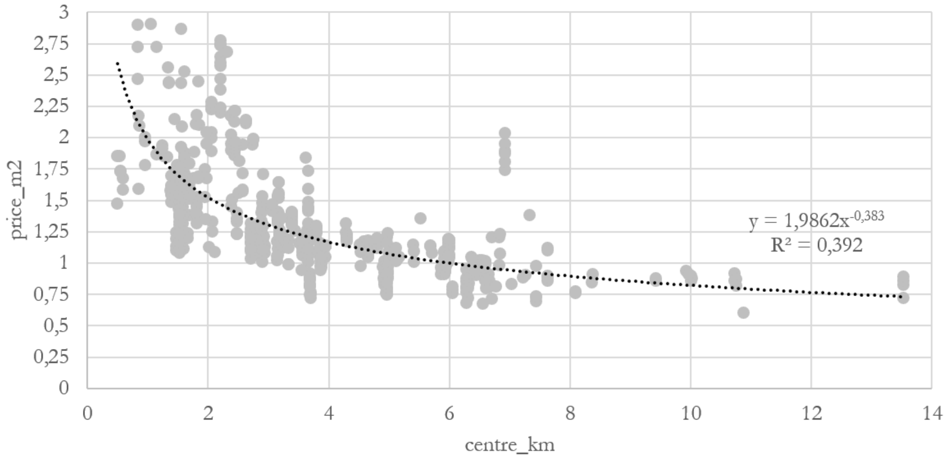

Figure 8. Relation between distance to city centre and price per sq. m of selected apartments in Vilnius

Source: own evaluation.

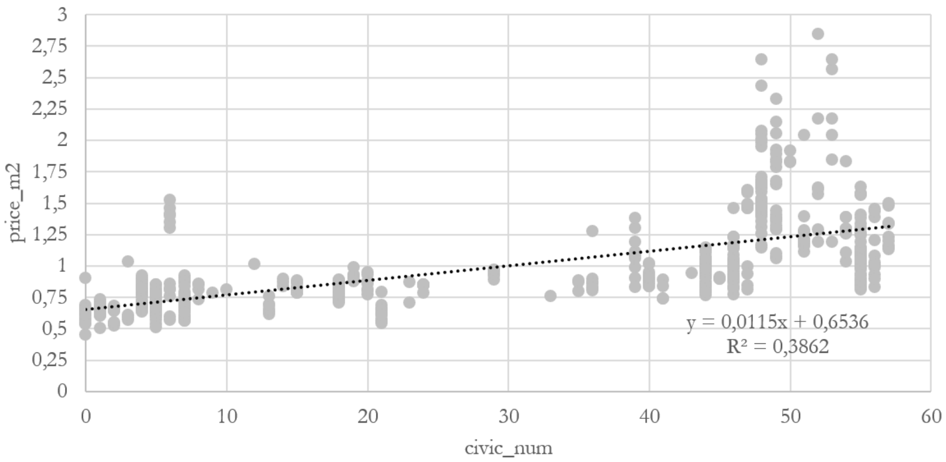

Figure 9. Relation between number of civic points and price per sq. m of selected apartments in Vilnius

Source: own evaluation.

In the 2nd stage the coefficients of prominent structural variables from the 1st stage were used to residualise spatially referenced apartments' market value data. We were using those coefficients to adjust spatial real estate market value data (price per sq. m) to eliminate prominent variance. After that, price per sq. m was also adjusted for location and neighbourhood properties to get the final spatially referenced residualised apartments' market value data. An apartment situated 6 km away from a city centre was selected as a reference for removing location trend (figure 8). An apartment with 30 civic points within 4 km distance was selected as a reference for removing neighbourhood properties trend (figure 9). These references' values were adjusted for Kaunas depending on its size. Civic points' variable co-move with distance to centre variable, therefore civic points were used. Civic points variable captures a location relative to the biggest concentration of civic points. In the end, 3D diagrams were created from spatially referenced residualised apartments' market value data for each city (figures 10-11). The natural neighbour interpolation was used to get the 3D diagrams of selected cities. The standard deviation of residualised apartments' market value variance across space in Vilnius – 985 EUR, the coefficient of variance – 39%. The standard deviation of residualised apartments' market value variance across space in Kaunas – 357 EUR, the coefficient of variance – 20%.

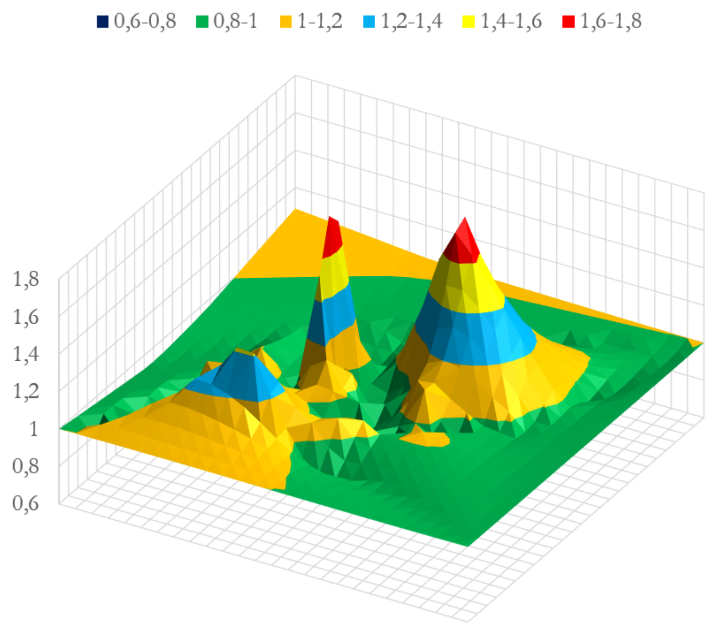

Figure 10. 3D diagram of residualised apartments' market value variance across space in Vilnius
Source: own evaluation.

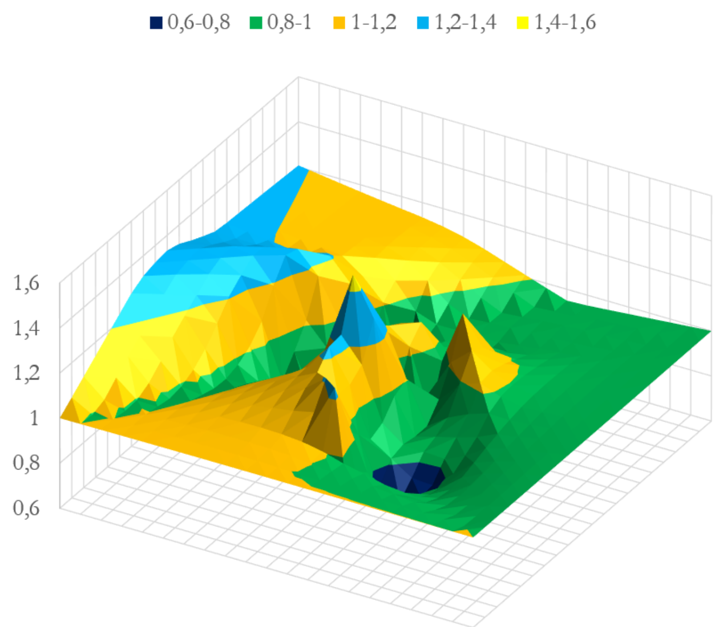

Figure 11. 3D diagram of residualised apartments' market value variance across space in Kaunas
Source: own evaluation.

The neighbourhood urban design and individual building architectural design variables are highly spatially dependent, therefore, the aim of this study is to identify the impact of spatial bubbles on real estate market value. However, the impact of architecture is yet to be confirmed by further research looking at whether these spatial bubbles correlate with the architectural quality. Also, time dimension could be added looking at previously sold spatially referenced apartments' market value. This would allow to test whether the spatial bubbles change over time and how quickly or whether the possible location bias would exist if spatial bubbles appeared to be constant. Further step can be market segmentation from buyer's perspective, meaning that buyers with some characteristics are looking for certain apartment characteristics, which might suggest that the price bubbles can be created by buyers, not architectural properties. While this research only touches the supply and demand from the product perspective, it is still a valuable insight into the spatial dependency research.

4. CONCLUSIONS

A significant amount of unexplained spatial variance was found inside a city. This phenomenon deserves more attention in real estate market value determination research. This also adds another dimension to real estate market bubbles that can be seen as the spatial market segmentation from local supply and demand perspective. While supply, demand and resulting submarkets are the core elements of real estate market value determination process, we argue that demand and resulting submarkets depend on the unexplained variables such as a neighbourhood urban design and an individual building architectural design.

The key aspect of the identification of spatial bubbles in real estate market is the fact that supply and demand are not global but rather local. Because of the nature of real estate, spatially arranged submarkets appear in microenvironments. Economics constructs the market value models in relation to supply and demand, however, the reasons behind lower or higher demand raise more questions and go beyond economics. We suggest merging the supply and demand models with architecture, representing the best use of existing space and resources. This holistic approach deepens the understanding of the structure of real estate market value determination process.

The position of location, structural, neighbourhood properties, neighbourhood urban design and individual building architectural design variables in hedonic models has been reconsidered. This raises a question about the position of architecture within these hedonic models. While all these variables are architectural ones, location, structural and neighbourhood properties are prominent, neighbourhood urban design and individual building architectural design are unexplained. While these unexplained variables are hard to measure, this raises a discussion of the extend of hedonic properties we can rely on while determining real estate market value.

We observed up to 39% of apartment market value unexplained variance across space and, therefore, identify the spatial bubbles in the housing market of the selected cities. The nature of this variance is yet to be confirmed, however, while applying hedonic properties to eliminate individual heterogeneity, it is obvious that these apartments differ in their architectural appearance and surroundings. The significance of these results comes from the awareness of existing variance across space. This suggests the possible use of such results for planning equally developed city districts to achieve better economic environment and welfare for the inhabitants of a city.

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