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Examining the Determinants of Residential Real Estate Prices. Evidence from Poland

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Abstract

Aim: The aim of the research is to provide a comprehensive account of the determinants of residential property prices in particular the financial ones. This is an important issue for the Central Bank as well as for commercial banks, as the financing of the housing market is an important factor for conducting monetary policy as well as for assessing the level of credit risk.

Methodology: An empirical survey method based on the pooled least squares (OLS) estimation model was used. Data published by the Central Statistical Office and the AMRON-SARFiN Centre were used. They were aggregated for voivodeships and quarters for the period 2010-2019.

Findings: The result of the analysis allows researchers of this topic as well as practitioners to identify the priority determinants of residential property prices in Poland, which turned out to be the financial factor, i.e. income (average monthly earnings) and demographic factor (new marriages).

Originality/Value: The main research's value is the identification of the other analysed determinants, such as the cost of construction, interest rates and the supply of houses, as insignificant determinants of prices in the Polish real estate market in the periods under study.

Keywords: financing residential real estate, price determinants, bank

1. Introduction

The development of the housing market is a very important element in the economic growth of a country. This is not only due to the construction production itself, but also to its consequences in the form of increased demand for finishing goods, home electronics and white goods and interior design elements, an additional important element being the increase in demand for housing loans.

The main motivation for conducting this study was the importance of the topic in the context of a rapidly growing wealthy society, especially its middle-aged population. Its financial aspect, but more importantly its social aspect, is influencing the positive perception of the future life in Poland. According to statistics, the Poles are getting richer every year (Wages and Salaries Data, 2020), and adding to this the natural strong national inclination to independent living (Eurostat, n.d.) is a powerful driver of demand for residential property.

Real estate prices all over the world have been increasing rapidly in recent years. This phenomenon attracts the attention of housing investors, real estate developers, central banks and governments. Shocks on the housing markets alter real estate construction, drive housing cycles (Augustyniak et al., 2014), and generate risk for financial institutions, hence all the sides of this market strongly desire the ability to predict the price trends of housing.

The aim of this article was to examine what are the determinants of house prices in Poland. The real estate market covers not only residential housing, but also commercial and industrial real estate, as well as land. The paper analyses only the residential market, as it may be seen as the most important property market. What is more, trends and price behaviour on residential real estate markets differ significantly from these observed in the non-residential sector. Thus, analysing all the markets at the same time would be a sizeable mistake.

The research hypothesis is: "The main determinants of housing prices in Poland are personal income, demography, mortgage interest rates, cost of construction and supply of houses". To reach the goal and to prove this hypothesis, the authors used the descriptive method and statistical model, based on Polish market data, published by the Central Statistical Office of Poland and Centrum AMRON-SARFiN (2012-2020). The data were aggregated for voivodeships and quarters for the 2010-2019 period. The chosen time frame was long enough to draw important conclusions, but excluded external factors such as the COVID-19 pandemic and the global financial crisis. The quarterly and voivodeship-level data provided a large enough sample for the model, particularly as more specific data were not publicly available.

As a result of the study, numerical values of factor-price relations were established. The eight most important factors influencing property prices were the following:

- income, demographic factors (Muellbauer & Murphy, 2008) rate of return, price sustainability, credit availability and construction cost (McQuinn & O'Reilly, 2008); these six, theoretically should have a positive impact;
- interest rate (Egert & Mihaljek, 2007) and supply (Sutton, 2002); two that should theoretically have a negative impact.

The implications obtained were that the results of the econometric model allowed to conclude that the main determinants of housing prices in Poland were:

- income; if the average monthly salary in Poland increases by PLN 100, housing prices will increase by 0.57%
- demography; if the number of new marriages increases by 1,000 in each voivodeship, housing prices will increase by 4%.

Moreover, the other analysed determinants proved to be insignificant price drivers. Similar conclusions can be drawn using a simple regression.

The article consists of seven sections starting with an introduction. Section two provides a general overview of the housing market. Section three comprises a literature review detailing the non-financial and financial determinants of house prices. The next section presents the data and the research sample including descriptive statistics of the sample, selecting a functional form. Section five gives the estimation of the fixed effects model, and section six the interpretation of the results. The final section discusses the conclusions.

2. General Outlook of Real Estate Market

The real estate market is an important part of the economy. One of the fastest growing industries is construction. It is estimated with data from the United Nations Economic Commission for Europe (UNECE, 2021) that this sector alone constituted around 6.3% of global GDP in 2019. Obviously there exist numerous other sectors, directly or indirectly related to real estate.

Maslow (1943) stated that having a shelter is one of the most important human needs. The situation on the real estate market affects, to a greater or lesser extent, the life of every person. A deterioration in market conditions results in a change of affordability of housing for potential buyers, but also affects the situation of homeowners. This eventually leads to changes in consumption, hence real estate is important from the point of view of the construction and manufacturing industries, as well as the financial and retail markets. All central banks and governments need to monitor the housing market situation and react accordingly, creating adequate monetary and fiscal policies.

The role of regulators regarding the real estate market is crucial. The specifics of the market, such as high capital intensity, rigidity of supply and time lags, make a macroeconomic imbalance easy to occur. Sudden changes of housing prices lead to severe consequences for the whole economy, an example of which was the global financial crisis of 2007-2009. It started with excessive lending by banks in the United States, which was the main reason of rocketing house prices there. The self-perpetuating mechanism of the rise of lending activities and the growth of real estate prices eventually ended up with drastic declines of values of credit collaterals – real estate. As a consequence, millions of borrowers defaulted and therefore exposed big financial institutions to the risk of going bankrupt. Even though governments tried to mitigate the negative effects of the US financial crisis, this was the main cause of the global recession and the Eurozone crisis.

One could summarise the above considerations with a single phrase: the real estate market is important. Yet, what is its place in the economy? As there are so many interactions within the housing--related market, how to organize them formally? An interesting division was presented by Kucharska--Stasiak (2006):

The figure shows the division of the real estate sector into the construction and real estate market. The former consists of entities which construct real estate, excluding other engineering projects. According to The Business Research Company (2020), “the construction market includes a number of items broadly classified as construction. In fact, we deal with items such as: new work, additions, alterations, maintenance and repairs. The real estate market consists of the rental market and the real estate investment market. The rental market is an important part of the real estate sector, although its importance varies from country to country. It is also called consumption market, because includes owners’ imputed rents, as well as utility payments.” It was estimated using data from the US Bureau

of Economic Analysis (2021) that in 2019, the rental market accounted for approximately 13% of US GDP. Furthermore, the real estate investment market positions itself between the money and capital markets. This is reasonable, as all of them demonstrate a strong desire of investors to achieve profits. Two types of real estate investing can be distinguished: direct and indirect. The first is simply buying land, a building or an apartment in order to make a profit, usually by renting it or selling later for higher price. Another way to invest directly in real estate is to enter into property syndication – a group of investors created to purchase and manage commercial real estate; they can be structured as corporations or limited partnerships. In the latter case, the investor is a limited partner, who is liable only to the amount they invested.

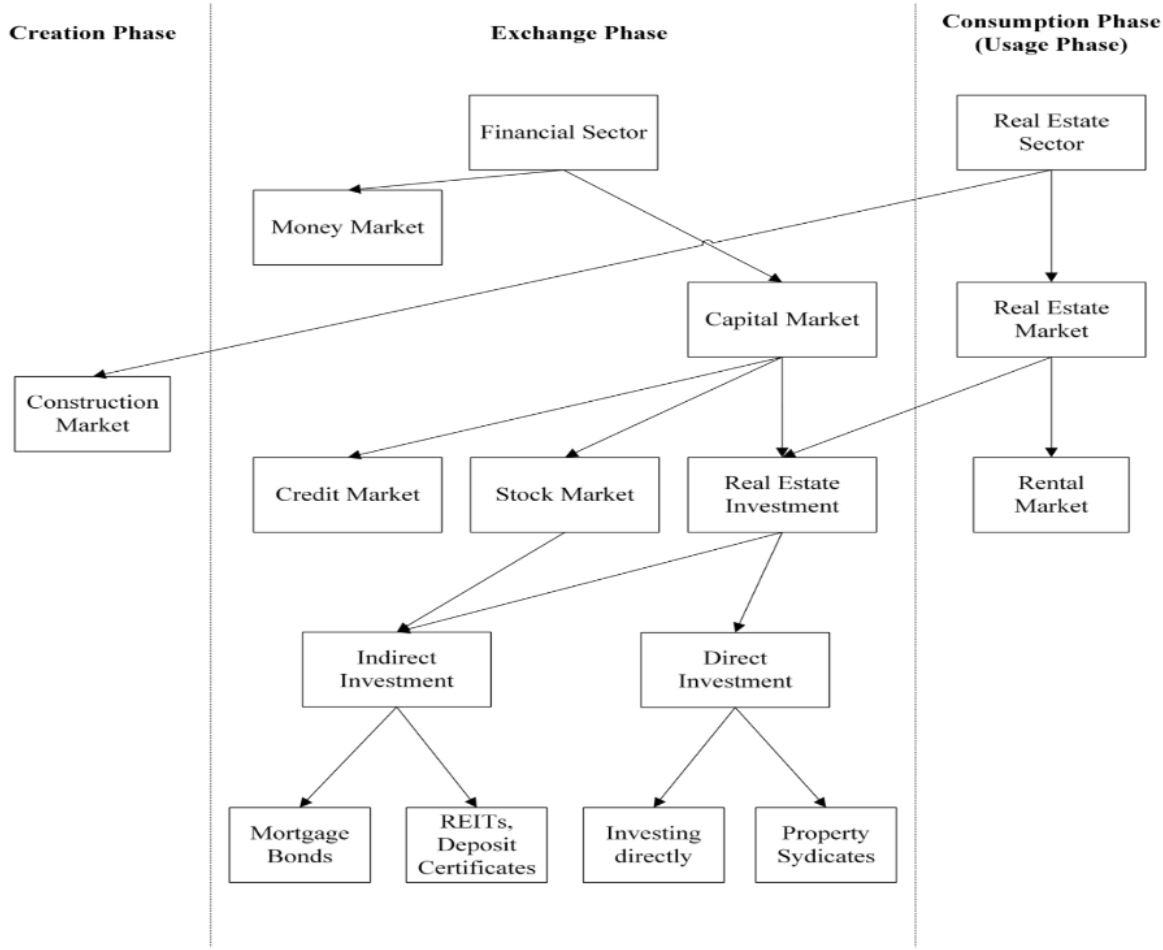

Fig. 1. Division of real estate market and its place in the economy

Source: own elaboration based on Kucharska-Stasiak (2006).

3. Literature Review

3.1. Non-financial Determinants of House Prices

Income, housing stock and demography factors can be considered as the most probable drivers of house prices (Muellbauer & Murphy, 2008). These mentioned determinants are included in the vast majority of econometrics studies trying to forecast house prices (Cao & Wei, 2017; Palacin & Shelburne, 2005). Income impact is usually analysed first.

- Income

The first chosen elaboration concerning the relation between personal income and house prices was the study by Case and Shiller (2004), who tried to find the justification for house price bubble theories, which were then frequently raised by the US media. This was done by analysing the steadiness of the relations between home prices and determinants of prices, with a focus on income. For this purpose, the quarterly data covering all US states for the 1985-2002 period were collected and analysed. The findings were as follows: for the seven states, where prices have been least volatile, the stability of the relation between prices and personal income was, as the authors stated, remarkable. Moreover, the explanatory power of income was up to 99% of the house price variation, whereas this relation was found to be very unstable in the most volatile states; only 45% of the data fitted the regression. The authors concluded that increases of real estate prices in the vast majority of the US could be explained almost entirely by personal income alone.

Vizek (2010) used cointegration and error-correction models to detect the short-run and long-run relations between house prices and price fundamentals, including income. Based on an analysis of 1995-2009 data from four post-transition and three developed EU countries, the author concluded that there was a long-term cointegration relation between house prices and both income and interest rate. Nonetheless, in the case of all post-transition countries, the income could be excluded from the model, not causing any serious worsening of the model quality. For the record, Poland was considered as post-transition country.

Another empirical study for eight post-transition countries including Poland was conducted by Egert and Mihaljek (2007), who also collected data from 19 developed OECD countries for comparison, and found strong positive relations between GDP per capita and house prices. Moreover, the interest rates, mortgage growth, demographic factors and the development of housing finance, were also identified as important house price determinants.

The hypothesis of the relevance of income as a house price driver was confirmed in a large number of other studies for different countries. Sutton (2002) concluded that income, to a great extent, was positively correlated with house prices in six developed countries, and the same was done for Ireland (McQuinn & O'Reilly, 2008), Australia and the USA (Posedel & Vizek, 2009), and also for Spain (Pagés & Maza, 2003).

The price determinants specifically in Poland were investigated by Leszczyński and Olszewski (2017). They analysed annual data for the 2002-2015 period for the 17 biggest cities in Poland and reached the conclusion that property prices do depend on fundamental variables such as wages, the rate of unemployment and the real interest rate. Furthermore, there was another interesting finding: the prices in the secondary market react significantly more strongly than the primary market prices, as a consequence of changes of mentioned determinants. The authors suggested that this may be due to the fact that, usually, completely different groups of people buy properties on those markets. The secondary market, in all likelihood, is selected by first-time buyers as it is cheaper than the primary market. Thus, it is expected that the primary market reacts less to economic fundamentals, and the secondary – the opposite.

However, some deny that income can be perceived as a house price driver. Cao and Wei (2017) tried to use the dynamic model averaging method to predict changes in house prices for thirty Chinese cities. The tested determinants were growth rates of consumer price index, gross domestic product, investment in real estate market, real disposable income, unemployment and also the financial determinants. It turned out that over a 30-years period, none of the determinants was superior to any other. The authors concluded that the Google search index has a bigger explanatory ability of house prices than any traditional macroeconomic variable.

A similar view was presented by Gallin (2006) checking the long-run relation between house prices and income. Based on the 23-year period of data for the United States, the author did not find evidence

for the existence of cointegration between the mentioned variables, and underlined the meaning of that finding: income perhaps is determinant of house prices, but there is no evidence about the strict association of the level of house prices and the level of income. Similarly, Drachmal (2011) tried to analyse the determinants of the increase of house prices in Poland, and in conclusion listed the determinants of house prices, omitting the income.

To conclude, the majority of numerous studies confirmed that an increase in personal income, household income or gross domestic product per capita results in increased residential real estate prices. Such a link is very intuitive. In the author's opinion, the relation should be based on the fact that demand for property, to a considerable extent, depends on the amount of disposable income. Moreover, real estate belons among normal goods, as the demand increases due to a rise in consumers' income. Thus, an increase in average personal income leads to higher housing demand, ceteris paribus, driving up the level of house prices. The income variable was included in the regression model analysed in next section.

- Rate of return

Another important and intuitive house price driver is the rate of return. Buying a house or flat certainly can be perceived as the start of a new investment, no matter if it is the investor's first property bought for housing purposes or the umpteenth small apartment for rent. Therefore, most topic related papers do acknowledge the rate of return as a major house price driver.

Yet, how to define the rate of return? The broad scope of the literature, again, is helpful, but first the determinants had to be predefined, for the purposes of clarity. Generally, the rate of return can be divided into two groups. First is the capital gain (or loss) on immovable assets, meaning the change of asset price due to the changes in the appraised value of a property. The second group are the determinants of user cost. This category consists of various components, depending on the paper.

The literature overview showed that two different approaches to analysing the rate of return can be found. Some authors treat capital gains described above as separate from user costs. (Muellbauer & Murphy, 2008; Hort, 1998), hence there is no possibility of positive user costs in case of house price appreciation on a decent level, in the sense of exceeding the total user costs. The opposite was the case for studies that qualify capital gains as a part of the user cost (Gallin, 2006; Case & Shiller, 2004). Regardless of the approach to the determinant allocation, all the mentioned authors recognised capital gains or losses as an important factor of house prices. The reasoning behind this, however, varies a lot. The most obvious component of the capital gain is a change in the price of real estate. The market value of a property increases, resulting in the profit for the owner if he/she decides to sell it. There is also a second, more interesting component, i.e. price persistence, which can increase the expectation of capital gains on a macro scale.

Essentially, price persistence is the tendency of a price to continue moving in its present direction. According to this phenomenon, assuming the house prices in Poland have been consistently growing for the last five years, there exists a high probability the prices will continue to grow, as proved by the previous studies. For example, Terrones (2004) analysed a sample of 18 countries during 1971-2004 and confirmed the high persistence of real house prices. Similarly, Hort (1998) showed this phenomenon to occur in the housing market of Sweden in the period 1967-1994. Sutton (2002) described the price persistence in housing as striking, confirmed by the fact that 85% of analysed advanced economies had been experiencing nominal house price growth by on an average of at least 6% yearly for forty to fifty years. Interesting conclusions can be drawn if one collates the price persistence concept with the price bubble theory; "a tendency to view housing as an investment is a defining characteristic of a housing bubble" (Case & Shiller, 2004). A logical conjecture is that widespread consideration of the housing market as profit-bearing may constitute robust encouragement for investing in residential real estate, which obviously can directly lead to strong increases of prices on the real estate market. What is more, the price persistence will likely reassure buyers about the very slight risk of such an investment, thus encouraging them to invest larger amounts. Additionally, there can exist a group of first-time buyers,

worried about the rapid increase in prices. As a consequence, they can be forced to buy the property immediately, as in later time, possibly, they will not be able to afford it. Taking into account this group, the straightforward recipe for a rapid price increase is thus obtained. In turn, the exponential rise of prices is the main condition for a price bubble.

An important part of the housing rate of return is the user cost. The above mentioned literature used different factors to define it, the most important of which is the mortgage or the opportunity cost, as the homeowner had to forgo some alternative investment; one should note the fundamentals of this relation. Unsurprisingly, the cheaper the mortgage, the more likely the consumer will buy the house (Sutton, 2002); moreover, the better the availability of the mortgage, the more consumers will get a credit and more properties will be sold. What makes a mortgage cheap and what are the determinants of mortgage availability? These concepts are extensively addressed in the next section.

Real estate constitutes assets that deteriorate over time, thus losing value – with time the roof is leaking, the plaster is coming off the wall, and the heating system is less and less effective – all of this is called depreciation. Many studies recognise depreciation as user cost (Case & Shiller 2004; Gallin, 2006; Hort, 1998). To prevent a property from decreasing in value, one ought to bear the cost of its maintenance and repairs. If it becomes more expensive, as the prices of construction materials grow or it becomes more difficult to hire a worker, the user cost grows. As a consequence, the demand for properties becomes smaller. The key conclusion is the following: the larger the depreciation, the higher the construction costs and eventually the lower the demand for real properties.

Last but not least, property taxation affects user cost, which can be defined as a compulsory financial charge imposed on the owner of real estate. Many authors agree that there exists a positive correlation between property tax rate and user cost, and thus a negative correlation between taxation and housing demand (Muellbauer & Murphy, 2008; Andre, 2016; Hort, 1998; Gallin, 2006; Case & Shiller, 2004). In Poland, there are two major taxes. The new homeowner is faced with a tax on a civil law transaction, which has to be paid by the buyer of real estate on the secondary market, and amounts to two percent of the transaction price. Additionally, every homeowner needs to pay property tax every year. The tax value constitutes on average less than 0.015% of the property value. As both tax rates had been constant in the 2010-2019 period, it was omitted in further parts of the study.

The logical conjecture is that all the mentioned components of rate of return were approximately constant over the analysed period. However, it turned out difficult to find trustworthy estimates of user cost and price persistence, hence both factors were omitted in next section of the study. Such a simplification does not affect the quality of the findings, but will allow formulating important conclusions in a consistent way.

- Demographic factors

Clearly, demographic factors have impact on house prices. The larger the population, the bigger the demand for housing. This logical conjecture seems to be proved by existing literature. The majority of topic-related literature qualifies demographic factors as a house price driver. Drachmal (2011) concluded that the cumulation of demographic and socio-cultural factors, such as rural-urban migration, the growing number of marriages, economic transformation and convergence, are the most important price drivers.

Important conclusions were also drawn by Heiborn (1994), who stated that the housing demand depends on population age and, is also the highest among the 25-44 group. Similarly, Mankiw and Weil (1989) found the entry of the Baby Boomers generation into its house-buying years to be the significant reason for the increase in prices of real estate in the 1970s in the United States. On the other hand, the authors predicted the substantial fall of housing prices over the period 1990-2010. In reality, in accordance to the US Bank for International Settlements (2021), the average real price of real estate grew by 25% at that time. One should note an extremely important fact, namely that the knowledge about the existence of the cause-effect relation does not necessarily imply the ability to model it and

to reliably measure its strength. Mankiw and Weil (1989) found that this was the case of the demography-housing prices relation: the complexity of demographic factors drivers, compounded by their potential interactions, makes this relation challenging to deal with.

Additionally, Leszczyński and Olszewski (2017) in empirical research regarding Poland, listed demographic aspects as one of house price drivers, but decided to exclude all of them from regressions. The reason was that these factors did not show enough variation to affect the regression to a sufficient degree, based on 2002-2015 data.

The above mentioned facts about the complexity of the demography-housing price relation could make the empirical model too complicated. Hence, finding a reliable estimator of demography factors was an important task. The most logical choice was to estimate this variable with the number of new marriages in 2010-2019 in Poland. Usually just after marriage, new couples try to buy their own place to live. Undoubtedly, this is a slight simplification but remains a reasonable way to estimate the influence of complicated demographic factors.

- Supply

Finally, the latter determinant 'supply' should be described. Posedel and Vizek (2009) used the multiple regression and SVAR models to analyse real estate price drivers in three EU-15 countries and, separately, in three Eastern European countries. Poland was assigned to the latter group. The authors found that in both groups of countries the supply was fixed, which means that no supply-side factor determined residential real estate prices in the short run.

Sutton (2002) stated that the supply is mainly defined by five main determinants: the price of land, construction costs, credit costs, supply restrictions and the price of houses. He considered the supply--side variables as difficult to obtain and did not include them into analysis. Moreover, Muellbauer and Murphy (2008) listed zoning and building regulations as main supply determinants.

In turn, Wagner (2016) suggested that only in the long term the supply adapts to the changes of the demand. Thus, one could deduct that in the short-run supply is constant, therefore the findings of case about inelasticity supply in the short term can be treated as synonymous.

There is an issue with the limited supply of housing in central and eastern Europe countries, as described by Egert and Mihaljek (2007). Due to the transition processes in these countries, they experienced a significant housing gap per 1000 inhabitants. Owing to the magnitude of shortages, even the newest, historically the highest levels of new housing construction have not changed the situation yet. Leszczyński and Olszewski (2017) obtained results that confirm this theory, but did not have grounds to reject the hypothesis that "the housing stock in Poland is insufficient to satisfy the growing housing needs, new supply is still not able to lower prices on both (primary and secondary) housing markets." Based on this, these authors found the supply of residential real estate in Poland remains at a constant level both in the short and in long run, and is inelastic.

- Cost of construction

Similarly to demography, supply is a complicated, multiperspective factor that affects the prices of real estate. The only way to include it in econometric model is to find an adequate and relatable estimator of it. In the next section, the assumption was made that the supply can be estimated by the number of square meters of residential real estate put into use. It can be also very informative to include in the model variable indicating the cost of construction. A positive correlation between construction cost and house price was expected.

3.2. Financial Determinants of House Prices

One of the most important determinants in the real estate market concerns financial factors, as supported both by the existing literature (Terrones, 2004; Sutton, 2002; Case & Shiller, 2004; Egert & Mihaljek, 2007; Posedel & Vizek, 2009; Główka, 2016; and others), and the available data (see Figure 2).

The figure depicts the estimated share of the value of transactions financed by mortgage loans in the total value of transactions. The estimations apply only to the primary real estate market in the seven biggest cities in Poland for the 2012-2019 period. As can be observed, the share of credited transactions fluctuated between 25% in the fourth quarter of 2017 and 52% in the third quarter of 2012, and the mean value for the presented period was 37%.

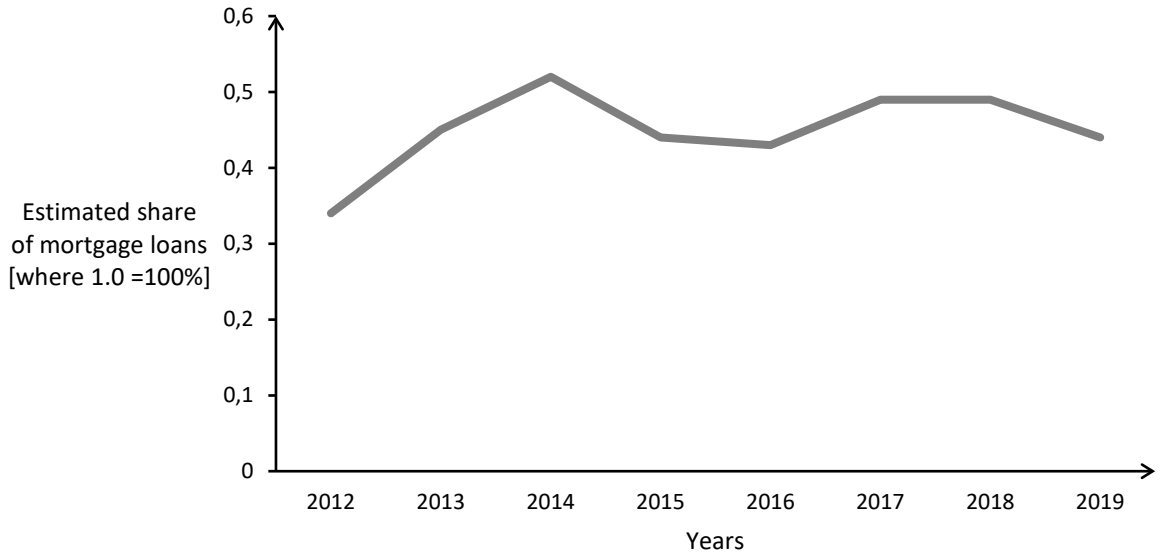

Fig. 2. Estimated share of the value of transactions financed by a mortgage loan in the total value of transactions on residential real estate market in Poland in 2012-2019

Source: own elaboration based on (NBP. Information on housing prices and the situation on the residential and commercial real estate markets in Poland in Q1 2012 – Q4 2019).

The data did not take into account the purchasing processes on the secondary real estate market because of the difficulty or even impossibility of acquiring such information. Nevertheless, primary market data are an effective way to show the collateral relation between the credit market and the real estate market. What is more, the subject literature proves that the share of credited transactions on the secondary market is at least as big as on the primary market. Leszczyński and Olszewski (2017) suggested that, with a high probability, the first-time buyers who need a mortgage to buy a property, choose the secondary market. The reason is the lower mean price of real estate on the secondary compared to the primary market. On the other hand, residential real estate investors, who are in possession of big amounts of capital and do not need external financing, most often choose housing available from the primary market. Another reason why financial determinants should be analysed, is the growing number of granted mortgages. In the 2016-19 period, the number of active mortgage contracts increased by 16.1%, while in 2012-2019 almost by 38%.

- Interest rate

The most important financial determinant is the interest rate. Główka (2016) stated that increases of credit costs, meaning interest rates, have a powerful negative influence on the level of activity of the real estate market, and concluded that low interest rates are a strong monetary stimulus of demand

for immovable assets, causing typical demand-pull inflation on the market. Similarly, Egert and Mihaljek (2007) proved a strong negative short-term and long-term relation between real interest rates and house prices, also confirmed by Hlavacek and Komarek (2009). Terrones (2004) found that the average correlation between house prices and interest rates in both short-term and long-term was negative. From the already cited study by Case and Shiller (2004), comparable conclusions can be drawn. The authors claimed that a substantial fall in interest rates accelerated the growth of real estate prices in the period 1995-2003, however, when analysing US data, they observed this relation only in some American cities.

Vizek (2010), with the use of cointegration and error-correction models, also proved the long-run cointegration relation of interest rates with house prices. Additionally, the author found that in all the analysed post-transition countries, interest rates could not be excluded from the model without the decrease of the quality of the model.

Moreover, Pagés and Maza (2003) found that nominal interest rate was the main determinant of prices on the Spanish real estate market. Gimeno and Martínez-Carrascal (2006) analysed mortgage and real estate markets and found an interdependence between them in the long run.

Sutton (2002) examined the relation of chosen economic indicators, including interest rates, with house price changes, stating that it exists and is important in determining prices of real estate. The same author, in another paper written in 2017, estimated that in countries like Poland, a 1% decrease in domestic short-term interest rates, combined with a corresponding decrease in the US real rate, causes an increase in house prices as high as three and a half percentage points, compared to the baseline, after three years.

The existing literature enables to assume the interest rate is a very important financial determinant of house prices. This assumption was verified in the empirical section of this article.

- Credit availability

Based on the literature, credit availability can be distinguished as second and the last financial determinant of house prices, for the pretty straightforward reason: the lower the availability of mortgages, the lower the value of credits granted and, the smaller the housing demand and, eventually, ceteris paribus, the higher the price of real estate.

Goodman et al. (2014) analysed this issue with the following approach: they estimated the number of mortgage loans that would be granted in 2012 using 2001 standards, which were greatly more liberal. Next, they compared the estimates with 2012 real-life data. It turned out that the much stricter requirements posed by banks caused a drop of 1.2 million in new loans in the United States in 2012 alone.

Another empirical study about credit availability was conducted by McQuinn and O'Reilly (2008) with the use of Irish data. In the first part of the paper, the authors proposed a theoretical model, in which the main determinant of demand for immovables was the amount of credit that an individual could borrow from a financial institution. This amount was assumed to be dependent on the income of the potential borrower and on the interest rates. The second part of the study was dedicated to the empirical test of the proposed model. The authors found there exists a long-term relation between credit availability and house prices. A similar concept was presented by Laufer and Paciorek (2016), who constructed a measure of mortgage loan credit availability and then verified its relation with the real estate market. They concluded that credit score thresholds, which can be considered as a measure of credit availability, have a very large negative effect on borrowing for housing purposes. Clearly, such an effect lowers the demand for real estate and thus can negatively impact the prices of housing, hence credit availability is recognised as one of the most important demand stimulating factor.

However, some authors reject the theory about the strength of credit availability-housing demand relation. Its author, Meltzer (1974), did not find any evidence that credit availability had an important or lasting effect on the consumer's purchase decision.

Taking all this into account, it seems that credit availability can impact on house prices. Nevertheless, from an econometric point of view, including this factor into the model, would be, most likely, a serious mistake. One should remember that credit availability mainly and directly depends on the personal income of the borrower and the interest rates applied on the market. Both factors already have been described and assumed to be included into the model. Hence, adding the extra variable that is primarily based on values that are already included in the model would be a perfect example of multicollinearity. Naturally, such a feature of econometric study would be very undesirable; therefore, credit availability was included in the empirical part.

To sum up, house prices may depend on many different external factors. The literature describes a wide range of price determinants, and the factors that can possibly influence real estate prices are as follows:

- income
- rate of return
- price persistence
- demographic factors
- supply
- cost of construction
- interest rate
- credit availability.

Figure 3 shows a scheme of the aforementioned determinants.

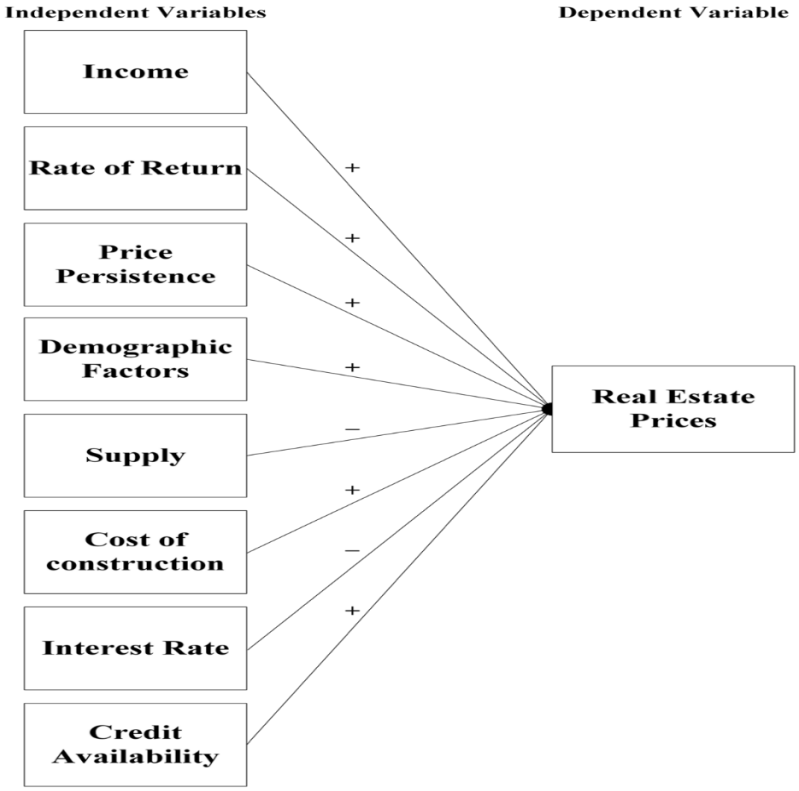

Fig. 3. Block diagram of the determinants of the real estate prices

Source: authors' analysis.

4. Data and Research Sample

In order to conduct the research, publicly available data from across Poland were collected. All the variables were aggregated for a given quarter; monthly data were transformed into an appropriate form, so that they correspond with the rest, covering the period from the first quarter of 2010 to the fourth quarter of 2019. This choice was not accidental – the 10-year period is long enough to be able to make reliable estimates. However, the data from the selected period should not be distorted by independent external factors. In 2010, one could have expected the stabilisation of abnormal trends on the real estate market, mainly resulting from the crisis from the previous years. In turn, the global COVID-19 pandemic, which broke out in the first quarter of 2020, significantly influenced real estate markets in Poland, in Europe and all over the world.

All the collected data were aggregated for voivodeships, the highest-level administrative division in Poland. The selection of data divided into voivodeships prompted a large number of observations. Additionally, not all the variables were available for smaller administrative units. Specified as above, the presented data were perfectly in line with the definition of panel data, namely: "[...] has observations on the same units in several different time periods [...]". The collected longitudinal data concern 16 units (voivodeships) and 40 time periods (quarters), in total it constitutes 640 observations for every variable. All the observations were imported into the Software Stata in order to conduct an econometric study.

In the model, the dependent variable is price – the average level of 1 square meter of residential real estates in a specific quarter in a specific voivodeship. This variable is expressed as the Price Index ("price" in Stata), where the value of the price level in the corresponding quarter of the previous period is equal to 100. These values are published by the Central Statistical Office (GUS). The explained variable is continuous and can take values from zero to infinity. The independent variables in the model are as follows:

- **Cost** ('cost' in Stata) is the average cost of construction of 1 sqm of residential real estate in a specific quarter in a specific voivodeship. All local authorities are obliged by law to publish these data every two quarters. Two values are published every six months in a public information bulletin issued for every voivodeship: the first one concerns the construction cost in the capital of the voivodeship, and the second one – the cost in the voivodship, excluding its capital city. In order to attain only one value per each quarter and per each area, the best way to establish weighting factors in which the observed values could be multiplied had to be found. This was done in the following way:

Formula 1: $$\boldsymbol{Wf_v = \frac{vv}{vv+vc}}$$

where: Wf_v – weighting factor for average value in voivodeship excluding capital city; vv – value of transactions in particular voivodeship in particular period, excluding capital city, expressed in Polish zloty; vc – value of transactions in particular capital city in particular period, expressed in Polish zloty.

Formula 2: $$\boldsymbol{Wf_c = 1 - Wf_v}$$

where: Wf_c – weighting factor for average value in capital city; Wf_v – weighting factor for average value in voivodeship excluding capital city

The calculated weighting factors were multiplied by the appropriate values of the cost of construction – in this way the precise cost of construction of 1 sqm for every voivodeship was calculated. The source of the data was GUS.

- **Demography** ('demography' in Stata) is the number of new marriages in a specific quarter for a specific voivodeship. The logical conjecture was that such values can be a good estimation of demographic trends in Poland, they are also simple to obtain and easy to use in the model.

Therefore, these values are used as estimators of demographic factors in Poland; the values come from GUS.

- **Income** ('income' in Stata) is the average monthly gross salaries in the domestic economy, published quarterly by GUS, in a specific quarter in a specific voivodeship.
- **Interest** ('interest' in Stata) is the average mortgage total interest rate. Such data were collected by Centrum AMRON-SARFiN (2012-2020) on a monthly basis. Quarterly values of mean interest rates were obtained by averaging data from three relevant months.
- **Supply** ('supply in Stata) is the number of sqm of residential real estate put into use in a specific quarter in a specific voivodeship. Data are available on the GUS webpage.

There are two additional variables, specific for panel data:

- **Cross-sectional variables**, indicating to which voivodeship the data are related. In order to conduct an econometric study, the names of all the administrative areas were sorted alphabetically and numbers in ascending order were assigned to them. Thus , in Stata:
  - Dolnośląskie Voivodeship was marked as 1
  - Kujawsko-Pomorskie Voivodeship was marked as 2
  - Lubelskie Voivodeship was marked as 3
  - Lubuskie Voivodeship was marked as 4
  - Łódzkie Voivodeship was marked as 5
  - Małopolskie Voivodeship was marked as 6
  - Mazowieckie Voivodeship was marked as 7
  - Opolskie Voivodeship was marked as 8
  - Podkarpackie Voivodeship was marked as 9
  - Podlaskie Voivodeship was marked as 10
  - Pomorskie Voivodeship was marked as 11
  - Śląskie Voivodeship was marked as 12
  - Świętokrzyskie Voivodeship was marked as 13
  - Warmińsko-Mazurskie Voivodeship was marked as 14
  - Wielkopolskie Voivodeship was marked as 15
  - Zachodniopomorskie Voivodeship was marked as 16.
- **Time-series variables**, from which the quarter indicating observation was presented. Again, data were sorted in chronological order and numbers in ascending order were assigned to them. In this way, in Stata, the first quarter of 2010 was marked 1, and the fourth quarter of 2019 – 40.

To sum up, the panel data set used in the analysis included 640 observations for every variable: for one dependent and five independent variables, therefore the total number of observations was 3840. All the data were collected and prepared according to the best econometric practices:

First, it was checked that all the observations concern regular time intervals.

Second, verification of the number of units (voivodeships) and the number of time periods (quarters) was done. Accordingly, it was concluded that the used panel data were neither short nor long.

Third, the conclusion that all the units, also called entities, have measurements in all periods was drawn, therefore the panel data were balanced.

Fourth, as the same units were observed for each quarter, the data set was a fixed panel.

Fifth, other potential problems such as too small data set or changes in measurement methods employed were ruled out.

Thus, the estimation process could begin.

4.1. Descriptive Statistics of the Sample

Table 1 presents descriptive statistics of all the variables.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Voivodeship	640	8.5	4.613	1	16
Time	640	20.5	11.552	1	40
Price	640	102.23	4.616	91.8	114.6
Cost	640	3868.17	434.19	2755.8	5468.85
Demography	640	3068.42	2449.95	318	13068
Income	640	3968.19	637.41	2825.99	6392.72
Interest	640	4.43	.84	3.45	6.18
Supply	640	586500.34	539511.4	46554	3551751

Source: authors' analysis.

Firstly, the above mentioned general insights about the presented data could be confirmed. It appears that in the 2010-2019 period, the mean change of house prices was 2.23% yearly, with a fairly high standard deviation. The maximum decrease of price was over 8% year to year, and the maximum increase at almost 15%. The average price of construction was 3868.17 PLN; moreover, in the examined period it fluctuated between 2755.8 PLN to 5468.85 PLN, depending on the voivodeship. The average income was 3968.19 PLN, with the lowest values of 2825.99 PLN and the highest of 6392.72 PLN. The average cost of external financing of real estate was 4.43%, while the number of square meters put into use was 586500.34.

It would be very informative to analyse the relations between the variables and to check their correlations. Hence, scatter plots of all the independent variables on the dependent one are presented below. The values of Pearson correlation coefficients between the mentioned variables for all the voivodeships are also presented.

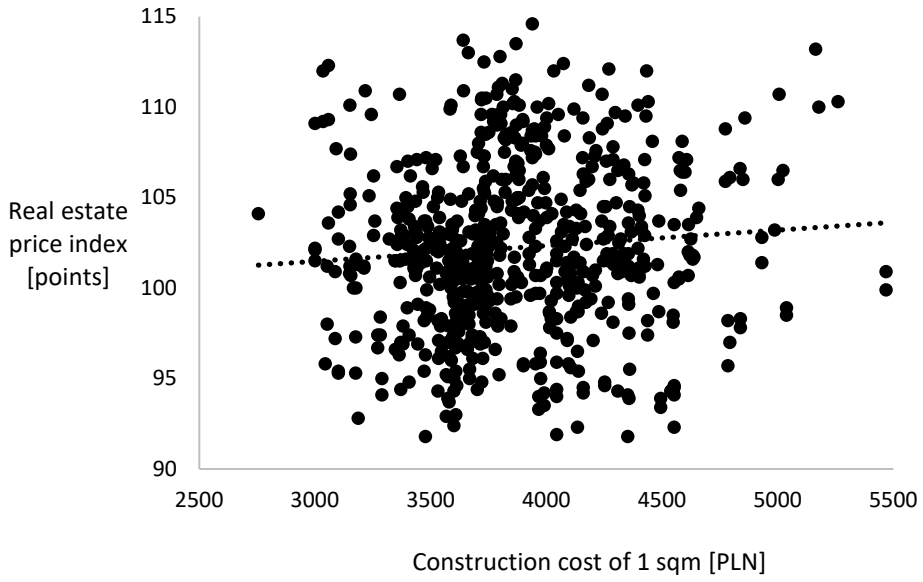

Fig. 4. Real estate price index and construction costs for all the voivodeships in 2010-2019

Source: authors' analysis based on price and cost variables.

Figure 4 is a scatter plot of the construction cost on real estate prices, where every dot represents values for both variables in a specific quarter for a specific voivodeship. The position of each dot on the vertical axis indicates the value of the price index in the specific time and region. In turn, the dot's position relative to the horizontal axis shows the construction cost. The dotted line shows the strength of the correlation between the two variables, called a trend line. Logically, it can be interchangeably used with the correlation coefficient. Hence, a perfect linear correlation exists if the trend line is at a 45 degree angle, or the correlation coefficient is equal to 1, whilst a flat trend line or a coefficient equal to 0 would mean the total lack of correlation. Different angles of the trendline and different values of the correlation coefficient should be interpreted in a similar manner. Returning to the figure, a trend line with slope that is near to the flow indicates a weak and probably unimportant correlation between the variables. The value of the correlation coefficient shown in Table 2 seems to confirm this observation.

Table 2. Correlation coefficients of the variables 'price' and 'cost' for 16 voivodeships, and for Poland for 2010-2019

No.	Region	Value of correlation coefficient
1	Dolnośląskie	0.2381
2	Kujawsko-Pomorskie	–0.0718
3	Lubelskie	0.2311
4	Lubuskie	0.394
5	Łódzkie	–0.5331
6	Małopolskie	0.4059
7	Mazowieckie	0.3148
8	Opolskie	0.0234
9	Podkarpackie	0.2017
10	Podlaskie	0.3752
11	Pomorskie	0.3718
12	Śląskie	0.3398
13	Świętokrzyskie	0.4173
14	Warmińsko-Mazurskie	0.4364
15	Wielkopolskie	0.0193
16	Zachodniopomorskie	0.6511
17	Poland	0.0811

Source: authors' analysis based on price and cost variables.

The values of the coefficients differ greatly at voivodeships level, from 0.5331 in Łódzkie to 0.6511 in Zachodniopomorskie, which means that in the former there was a strong negative correlation, and in the latter – a strong positive one. In eight out of the rest of the analysed regions, a moderate positive correlation between house prices and cost could be observed, what is logical. Next, one should look at Figure 5.

The position of every dot relative to the vertical axis depicts the value of the house price index, and relative to the horizontal axis – the number of new marriages. As can be observed, the densest area of the figure is for values of price index between 95 and 105 points and for number of new marriages smaller than 4000 per quarter. The trendline, as in the previous case, indicates very slight and rather negligible correlation between these two parameters. The value of Pearson's correlation coefficient was approximately 0, which indicated no correlation, as shown in Table 3.

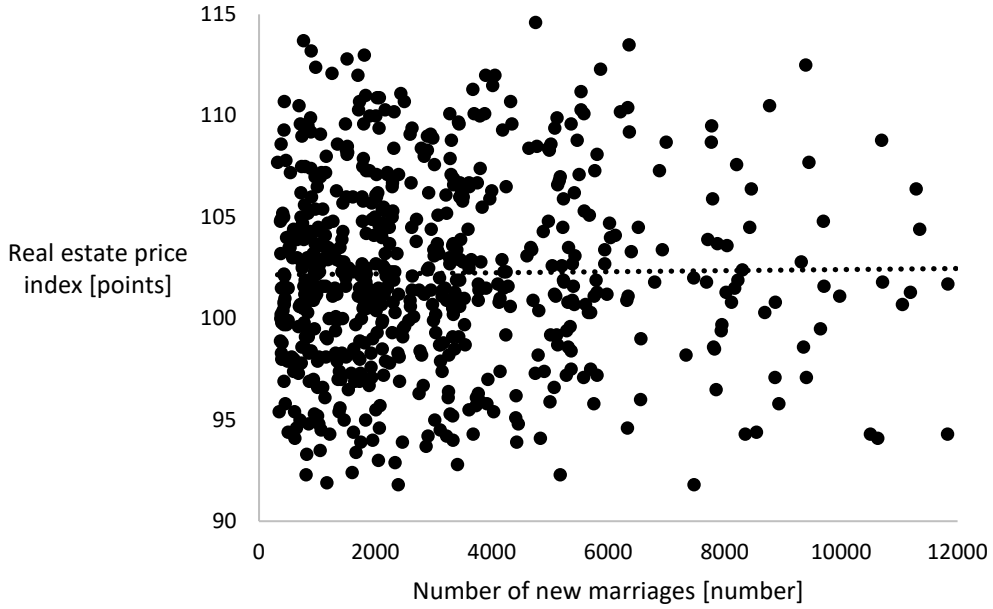

Fig. 5. Real estate price index and number of new marriages for all the voivodeships in 2010-2019

Source: authors' analysis based on price and demography variables.

Table 3. Correlation coefficients of variables 'price' and 'demography' for 16 voivodeships, and for Poland for 2010-2019

No.	Region	Value of correlation coefficient
1	Dolnośląskie	0.0674
2	Kujawsko-Pomorskie	0.0688
3	Lubelskie	0.1764
4	Lubuskie	0.0273
5	Łódzkie	–0.0045
6	Małopolskie	–0.0111
7	Mazowieckie	0.0116
8	Opolskie	–0.0005
9	Podkarpackie	0.0671
10	Podlaskie	0.0395
11	Pomorskie	0.1133
12	Śląskie	–0.1123
13	Świętokrzyskie	–0.0067
14	Warmińsko-Mazurskie	0.011
15	Wielkopolskie	0.0373
16	Zachodniopomorskie	0.0192
17	Poland	0.014

Source: authors' analysis based on price and demography variables.

Interestingly, all the values of other coefficients are close to zero, which denotes lack of correlation. This was surprising, therefore needs to be analysed to a greater extent with more advanced econometric tools.

Figure 6 depicts the correlation between real estate prices and interest rates. As demonstrated in the previous section, one can expect this correlation to be negative.

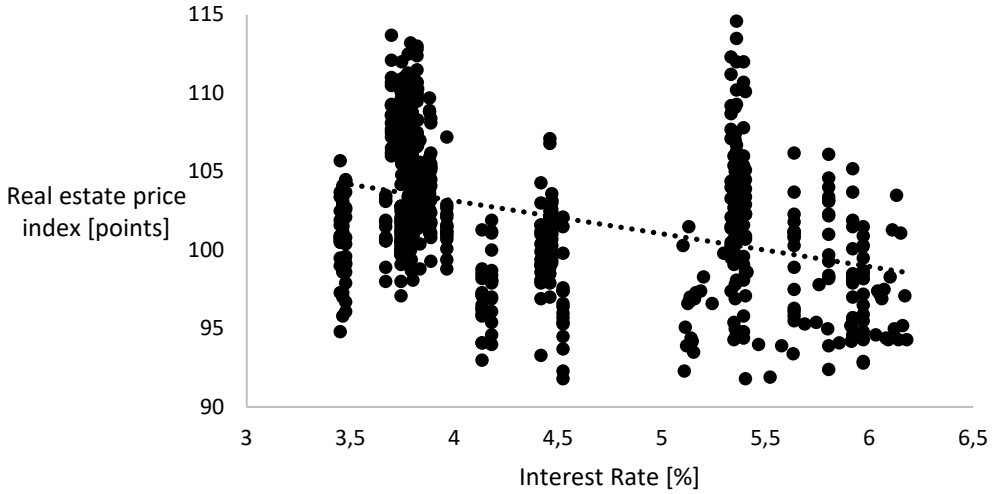

Fig. 6. Real estate price index and interest rates for all the voivodeships in 2010-2019

Source: authors' analysis based on price and demography variables.

As can be deduced both from the figure above and the value of Pearson's coefficient in Table 4, there exists a moderate negative correlation between house prices and demography factors. Its power differs from voivodeship to voivodeship, with the weakest values of the correlation of –0.0511 in Lubelskie Voivodeship, and the strongest values of correlation of –0.6107 in Mazowieckie Voivodeship. In all the regions only negative values of the coefficients could be observed, which is consistent with the literature overview presented in the previous section. In 10 out of the 17 areas, the coefficients indicated a non-negligible relation between the mentioned variables.

Table 4. Correlation coefficients of variables price and interest for 16 voivodeships and for Poland for 2010-2019

No.	Region	Value of correlation coefficient
1	Dolnośląskie	–0.2736
2	Kujawsko-Pomorskie	–0.2916
3	Lubelskie	–0.0511
4	Lubuskie	–0.4934
5	Łódzkie	–0.4701
6	Małopolskie	–0.2854
7	Mazowieckie	–0.6107
8	Opolskie	–0.2652
9	Podkarpackie	–0.2454
10	Podlaskie	–0.5533
11	Pomorskie	–0.4889
12	Śląskie	–0.3318
13	Świętokrzyskie	–0.1041
14	Warmińsko-Mazurskie	–0.6324
15	Wielkopolskie	–0.4353
16	Zachodniopomorskie	–0.6353
17	Poland	–0.3824

Source: authors' analysis based on price and interest variables.

The correlation of prices and income was checked next. The results can be seen in Figure 7.

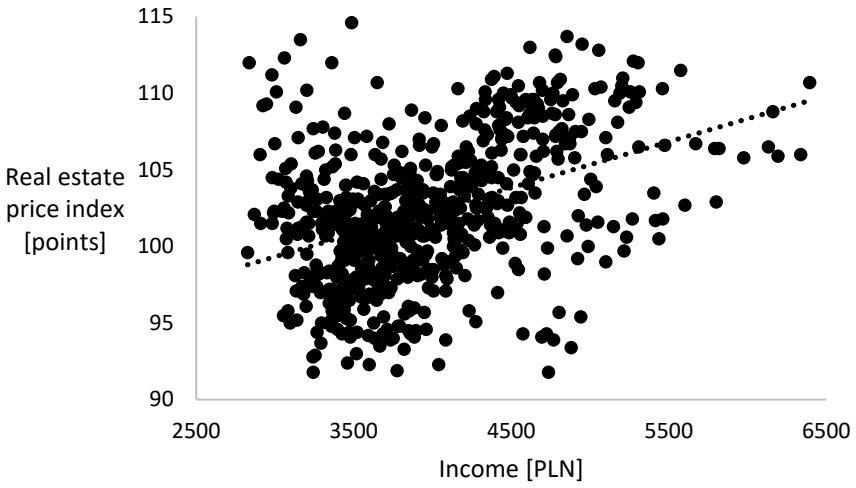

Fig. 7. Real estate price index and average personal income for all the voivodeships in 2010-2019

Source: authors' analysis based on price and income variables.

Table 5. Correlation coefficients of variables price and income for 16 voivodeships and for Poland in 2010-2019

No.	Region	Value of correlation coefficient
1	Dolnośląskie	0.3791
2	Kujawsko-Pomorskie	0.5350
3	Lubelskie	0.2003
4	Lubuskie	0.7009
5	Łódzkie	0.6936
6	Małopolskie	0.3767
7	Mazowieckie	0.7137
8	Opolskie	0.5294
9	Podkarpackie	0.3401
10	Podlaskie	0.7074
11	Pomorskie	0.6786
12	Śląskie	0.5935
13	Świętokrzyskie	0.4891
14	Warmińsko-Mazurskie	0.7103
15	Wielkopolskie	0.5793
16	Zachodniopomorskie	0.8235
17	Poland	0.4146

Source: authors' analysis based on price and income variables.

It appears that income and house prices were moderately strong, and positively correlated. The values of all the coefficients were relatively high. One should note in particular the correlations in Lubuskie, Łódzkie, Mazowieckie, Podlaskie, Warmińsko-Mazurskie and Zachodniopomorskie, where coefficients higher than 0.7 could be observed, denoting strong positive linear relation between house prices and income. In the rest of the voivodeships, only positive correlations could be observed, which were rather strong. These conclusions are in line with the existing literature, where the authors often stressed the strength of this income-price relation.

The last examined correlation was between real estate prices and the number of square meters of housing put into use in a specific quarter and a specific region. For the results at country level see Figure 8.

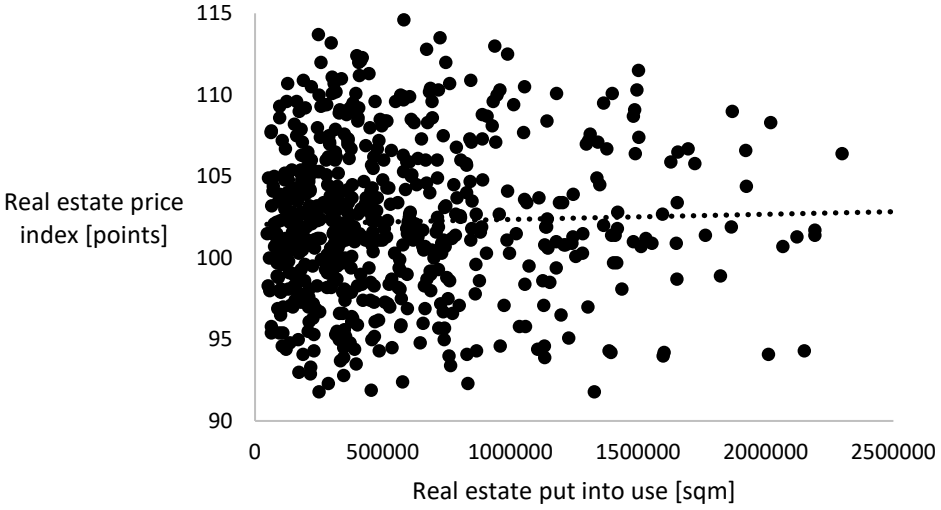

Fig. 8. Real estate price index and number of square meters of houses put into use for all the voivodeships in period 2010-2019

Source: authors' analysis based on price and supply variables.

The biggest density of data points could be observed on the left side of the scatter plot. As previously, most of the data were located close to the 100 point level on the vertical axis. The dotted line which depicts the trend is nearly flat, showing no correlation between two variables. The values of the correlation coefficients also shows a rather negligible relation for all the regions.

Table 6. Correlation coefficients of variables price and supply for 16 voivodeships and for Poland for 2010-2019

No.	Region	Value of correlation coefficient
1	Dolnośląskie	0.0322
2	Kujawsko-Pomorskie	0.1528
3	Lubelskie	0.0591
4	Lubuskie	0.3041
5	Łódzkie	0.1099
6	Małopolskie	–0.0347
7	Mazowieckie	0.168
8	Opolskie	0.1125
9	Podkarpackie	0.0735
10	Podlaskie	0.2538
11	Pomorskie	0.1715
12	Śląskie	0.1165
13	Świętokrzyskie	0.1039
14	Warmińsko-Mazurskie	–0.0015
15	Wielkopolskie	0.2176
16	Zachodniopomorskie	0.137
17	Poland	0.037

Source: authors' analysis based on price and supply variables.

To sum up, the use of the correlation coefficients enabled to draw the following conclusions:

- correlation between real estate prices and cost of construction could not be clearly specified
- correlation between real estate prices and demography factors does not exist
- correlation between real estate prices and interest rates is negative
- correlation between real estate prices and income is strongly positive
- correlation between real estate prices and supply does not exist.

However, it needs to be remembered that a plain correlation is undoubtedly a simple tool, hence these results can be oversimplified and thus, falsely describe the reality. Taking this into account, there is a strong need to use more advanced econometric tools. A more developed method of analysis is presented in the following sections.

4.2. Selecting a Functional Form

In developing a more sophisticated kind of data research, an econometric model is essential. For this purpose, a question about the most appropriate form of such a model needs to be answered first. The best literature overview and most accurate data is not enough if the chosen functional form is wrong. The typical procedure is to start with a pooled OLS estimation, because this method is fairly straightforward, and the correctness of its choice can be easily verified.

- Pooled OLS

There are six fundamental assumptions of Ordinary Least Squares:

- linearity – linear function of independent variables and error terms formulates dependent variable
- exogeneity – expected value of error term is zero
- homoskedasticity – error terms have constant variance
- non-autocorrelation – error terms are not related with each other
- independent variables are not random but fixed in repeated samples
- no multicollinearity – there can be no exact linear relations among the independent variables.

All the assumptions need to be fulfilled in order to use the pooled OLS, otherwise the violation of any of them makes using the Ordinary Least Squares method inappropriate. It is easiest to check the condition of homoskedasticity.

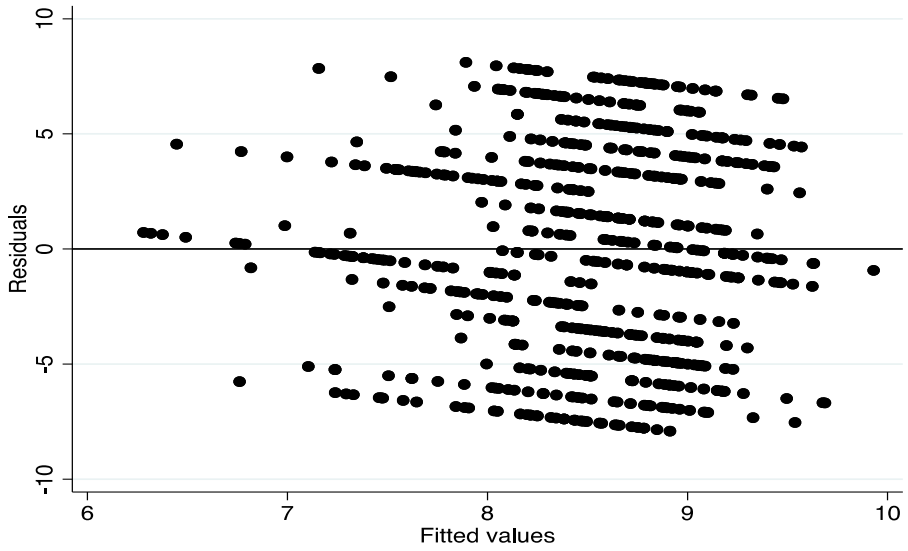

Fig. 9. Homoscedasticity test

Source: authors' analysis based on price, cost, demography, income, interest and supply variables.

A close inspection suggests that data points seem to spread out, which is an indicator for heteroskedasticity, and the homoskedasticity test, called White test, was also conducted. After using appropriate formulas and simple calculations, the *p*-value obtained was near 0 (0.0000). Thus, the null hypothesis of homoscedasticity can be strongly rejected.

From proof that data is heteroscedastic it can be concluded that the OLS method should not be used in estimation. Therefore, there still exists a need to look for the appropriate model; fixed or random effects models are probably more suitable.

- Fixed versus random effects

Panel data models identify the fixed and random effects of individual (voivodeship) or time (quarters), and the key difference between the two models is the role of dummy variables. In the random effects model, the parameter estimate of the dummy variable is an error component, whereas in the fixed effects model it is a part of intercept. Having mentioned the theoretical concept, a much more important question arises: how to decide which model is more appropriate? This is pretty straightforward, as it is enough to conduct the Hausman specification test that compares both of them. If the null hypothesis, which says that the individual effects are uncorrelated with the other regressors, is rejected, a fixed effects model is more favourable than a random effects model.

To check this, the appropriate function in Stata was used. The obtained *p*-value was near 0, which suggests rejection of the null hypothesis; therefore, the fixed effects model appears to be a better choice.

To ensure that the fixed model is appropriate, the overall *F*-test was checked. In such a case, the null hypothesis is that all independent variables have coefficients equal to zero. As expected, the ‘-value was small enough to reject null, and thus the use of the fixed effect model was confirmed to be appropriate.

5. Estimating the Fixed Effects Model

There exist two ways of estimating fixed effects. The first method is called the ‘within’ estimation, the second – the least squares dummy variables estimation (LSDV). Both of them were conducted and it was concluded that the latter one was the better choice, as the LSDV regression indicated higher values of goodness-of-fit.

The LSDV estimation method enabled examining fixed effects by introducing unit dummy variables, and again the units were voivodeships. The dummy variable g1 is set to 1 for voivodeship 1 (Dolnośląskie, as set above), and 0 for other voivodeships. Similarly, g2 is set to 1 for voivodeship 2 (Kujawsko-Pomorskie) and 0 for any other, and so on, up to g16.

Thus, the estimated model has the following form:

Formula 3:

$$price_i = \beta_0 + \beta_1 cost_i + \beta_2 demography_i + \beta_3 income_i + \beta_4 interest_i + \beta_5 supply_i + \sum_{i=1}^{7} u_i\, g_i + \sum_{i=9}^{16} u_i\, g_i + \varepsilon_i$$

where: $price_i$ = real estate price index
β_0 = intercept
β_1 =coefficient of cost variable
$cost_i$ = cost variable

β_2 = coefficient of demography variable
$demography_i$ = demography variable
β_3 = coefficient of income variable
$income_i$ = income variable
β_4 = coefficient of interest variable
$interest_i$ = interest variable
β_5 = coefficient of supply variable
$supply_i$ = supply variable
u_i = coefficient of ith-dummy variable
g_i = ith-dummy variable
ε_i = error term

Please note that one of the sixteen dummies, g8 (0.g8), was excluded from regression, and was used as a reference group. This is a standard procedure to avoid perfect multicollinearity in a model. The results of regression for the model are presented in Table 7.

Table 7. Linear regression results

Price	Coef.	St.Err.	*t*-value	*p*-value	[95%	CI]	Sig
g1	–2.6535	0.9600	–2.76	0.0059	–4.5388	–0.7682	***
g2	2.2932	0.9162	2.50	0.0126	0.4939	4.0925	**
g3	1.3532	0.8554	1.58	0.1142	–0.3267	3.0331	
g4	2.1360	0.8475	2.52	0.0120	0.4716	3.8003	**
g5	0.3551	0.8723	0.41	0.6841	–1.3579	2.0680	
g6	–1.2919	1.0211	–1.27	0.2063	–3.2971	0.7133	
g7	–9.4647	1.3598	–6.96	0.0000	–12.1351	–6.7942	***
0.g8	0.0000	.	.	.	.	.	
g9	2.7475	0.8646	3.18	0.0016	1.0495	4.4454	***
g10	0.5726	0.8566	0.67	0.5041	–1.1096	2.2548	
g11	–1.9794	1.0453	–1.89	0.0588	–4.0323	0.0734	*
g12	–2.6143	0.9587	–2.73	0.0066	–4.4970	–0.7315	***
g13	1.3533	0.8461	1.60	0.1102	–0.3083	3.0149	
g14	0.8910	0.8715	1.02	0.3070	–0.8204	2.6025	
g15	–0.5928	0.9963	–0.60	0.5521	–2.5495	1.3638	
g16	–0.8073	0.8514	–0.95	0.3434	–2.4793	0.8647	
cost	0.0006	0.0006	0.91	0.3639	–0.0007	0.0018	
Demography	0.0004	0.0001	4.34	0.0000	0.0002	0.0005	***
Income	0.0057	0.0005	12.64	0.0000	0.0049	0.0066	***
Interest	0.3288	0.2564	1.28	0.2002	–0.1748	0.8324	
Supply	–7.12e-07	4.64e-07	–1.54	0.1250	–1.52e-06	1.98e-07	
Constant	75.5480	3.1529	23.96	0.0000	69.3564	81.7396	***

Mean dependent var	102.2278	SD dependent var	4.6161
R-squared	0.3577	Number of obs.	640.0000
F-test	17.2399	Prob > *F*	0.0000
Akaike crit. (AIC)	3531.6773	Bayesian crit. (BIC)	3625.3681

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: authors' analysis based on price, cost, demography, income, interest and supply variables.

The presented regression can be quite confusing at first, hence a detailed description is given. In the fixed effect model each unit (voivodeship) has its own intercept but shares the same coefficients of independent variables. Thus, one may consider how to get a voivodeship specific intercept and how to interpret the dummy coefficients u_1-u_{16}, which is pretty straightforward. As mentioned before, the 8th dummy variable should be treated as the reference unit, therefore the regression for Opolskie, the 8th voivodeship in alphabetical order, is as follows:

Voivodeship 8

$$price_8 = 75.5480 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

Each of the other u_i represent deviation of its voivodeship-specific intercept from the baseline intercept 75.5480. For example, u_9 means that the intercept of Podkarpackie is 2.7475 higher than the baseline. One ought to remember that in this case all unit dummies other than g9 are zero. Therefore, its intercept is 78.2955=75.5480 + 2.7475[1].

Similarly, other intercepts were computed and eventually sixteen regression equations were obtained, as shown in Appendix 1.

Again, note that all regressors coefficients are the same, regardless of voivodeship. The coefficients should be interpreted in such a manner:

The intercept of Voivodeship 1 is 2.6535 smaller than that of the baseline intercept and this deviation is statistically discernible from zero at the .05 level ($p < .0059$).

The intercept of Voivodeship 2 is 2.2932 larger than that of the baseline intercept ($p < .0126$).

The intercept of Voivodeship 3 is 1.3532 larger than that of the baseline intercept, but this deviation is not statistically significant at the .05 significance level ($p < .1142$).

As in these examples, '*g*'s that have large *p*-values (>.05), are not statistically significant and thus do not deviate from the baseline intercept (intercept of voivodeship 8).

6. Interpretation of the Results

As can be observed in the table above, both essential goodness-of-fit measures, *F*-test and its significance (Prob>*F*), imply that the model is significant. The sum of squares coming from models is slightly above 4871, and that coming from errors – almost 8745. There are 619 degrees of freedom for errors and the total number of observations is 640. The proportion of the variance for a dependent variable that is explained by regressors, *R*-squared, is 35.77%, which is much 'better' in comparison with the pooled OLS estimation (23.26%).

Using the fixed model implies that all the regressors have the same standardised coefficients, but different intercepts. The focus can be shifted to the former, as the latter one was reported previously.

For a one unit increase in the cost of construction, the average price increases by 0.0006 units. This can be interpreted in the following way: if the cost of construction increases by PLN 1000, The average price of 1 sqm of residential real estate increases by 0.6 percentage points. Surprisingly, this variable is not statistically significant at the .05 significance level ($p < .3639$). This means that the results of the model suggest that there is no relation between cost of construction and price of real properties. The standard error was .0006. At this point, one should refer to the findings of Egert and Mihaljek (2007),

[1] A more formal computation would be 78.2955 = 75.5480 + (-2.6535)*0 + (2.2932)*0 + (1.3532)*0 + (2.1360)*0 + (0.3551)* 0 + (-1.2919)*0 + (-9.4647)*0 + (0.0000)*0 + (2.7475)*1 + (0.5726)*0 + (-1.9794)*0 + (-2.6143)*0 + (1.3533)*0 + (0.8910)*0 + (-0.5928)*0 + (-0.8073)*0. Clearly, this type of computation can be omitted for simplicity reasons.

as well as Leszczyński and Olszewski (2017), that a significant housing gap is a problem in Central and Eastern European countries, due to the systemic transformation processes.

Whenever the number of new marriages increases by 1000, the average price increases by 4 percentage points. This relation can be perceived as interestingly strong, but the model results confirm that the demography variable was significant ($p < .0000$). The standard error was .0001.

The income variable has a coefficient equal to 0.0057. Therefore, if the mean income in Poland increases by 100 PLN, an increase in the average price of 1 sqm by 0.57 percentage point can be expected. The income variable was significant ($p < .0000$). The standard error was .0005.

For a one percentage point increase in the mortgage interest rate, the average price increases by 0.3288. Such a connection is contrary to the analysed literature, but one cannot forget that the interest variable was not significant ($p < .2564$). This means that the relation between interest rates and house prices did not occur. The standard error was .2564. For further discussion, one should recall here the conclusions drawn by Case and Shiller (2004), who argued that a significant fall in interest rates accelerated house price growth between 1995 and 2003 (data from some cities in the USA). Vizek (2010) proved a long-run cointegrating relation between interest rates and house prices. The author found that in all the post-transition countries analysed, interest rates could not be excluded from the model without reducing the quality of the model.

The supply variable was also not significant ($p < .1250$). If it were, the higher supply of residential real estate would increase its prices, which is contrary to logic. To be more specific, the growth of supply by one million sqm[2] would increase house prices by 0.712 percentage points. As the relation was not significant, it should be omitted. The standard error was .000000464.

7. Conclusion

The knowledge of the factors that impact house prices could be revolutionary, as it would enable governments and central banks to create more effective fiscal and monetary policies. This could stabilise trends of prices of real estate and eliminate undesirable phenomena. In turn, the stability of the market could facilitate the satisfaction of the housing needs, in which case banks would be able to operate at lower levels of risk. Moreover, real estate developers would be able to start new investments without any major concern about the situation on the market when it comes to selling completed properties.

The authors conducted an investigation of house prices determinants that could help all the parties to the market to make appropriate decisions. Additionally, the study attempted to establish the numerical values of factor-price relations. Conducting a broad overview of both the global and Polish real estate markets was an important part of the research, as well as essential for understanding the importance of the chosen subject. The occurrence of certain phenomena was proved with a comprehensive analysis of the existing literature. The eight most important house price drivers were identified:

- six that theoretically should positively impact house prices: income, rate of return, price persistence, demographic factors, credit availability and cost of construction
- two that theoretically should negatively impact house prices: interest rate and supply.

The price factors distinguished within the overview of literature were checked for the possibility of use in the empirical analysis. The factors that that were impossible to obtain, or their use in the

[2] One million sqm is not an abstractly big number, as the mean supply in all the voivodeships was quarterly 9.384 million sqm.

econometric study was invalid, were rejected. A simple linear method was used as the first econometric tool. The verification of its results with a more complicated, fixed effects regression model was carried out.

The hypothesis tested in this paper was: “The main determinants of housing prices in Poland are: personal income, demography, mortgage interest rates, cost of construction and supply of houses”. The results of the econometric model enabled to conclude that this was partially proven. In fact, the main determinants of house prices in Poland are:

- income; if the average monthly salary in Poland increases by 100 PLN, house prices increase by 0.57%
- demography; if the number of new marriages increases by 1000 in every voivodeship, house prices increase by 4%.

What is more, the rest of the analysed determinants, such as cost of construction, interest rates and supply of housing were found to be insignificant price determinants in the Polish real estate market. Similar conclusions could be drawn with the use of a simple regression. Therefore, these factors cannot be perceived as those that impact real estate prices in the Polish market in the 2010-2019 period.

The limitations of this study include the lack of consideration of a new phenomenon related to the technological revolution enabling the common practice of remote work (legally sanctioned in Poland). This factor affects the dynamics of non-residential real estate prices in markets where until recently there was a very wide range of prices.

The possibilities of future research in this area should be expanded to include factors not included in this study, namely regulatory and sociological changes. The first concerns the preparation of restrictive technical requirements for new investment (and also for the existing projects), which will result in a significant increase in the costs of construction.

The second, is the expected change in the tendency to own real estate, typical of the older generation of Poles. The younger generation is more inclined to rent due to the ease of changing places of residence. On the other hand, greater mobility opens up wider opportunities for better employment.

Appendix 1. Regression Equations for Voivodeships

$$price_1 = 72.8945 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_2 = 77.8412 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_3 = 76.9012 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_4 = 77.6840 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_5 = 75.9031 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_6 = 74.2561 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_7 = 66.0833 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_8 = 75.5480 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_9 = 78.2955 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{10} = 76.1206 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{11} = 73.5686 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{12} = 72.9337 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{13} = 76.9013 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{14} = 76.4390 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{15} = 74.9552 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

$$price_{16} = 74.7407 + 0.0006 * cost_i + 0.0004 * demography_i + 0.0057 * income_i + 0.3288 * interest_i + 0.000000712 * supply_i$$

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Badanie determinant cen nieruchomości mieszkaniowych. Przykład Polski

Streszczenie

Cel: Celem badania jest kompleksowe przedstawienie determinant cen nieruchomości mieszkaniowych w szczególności tych finansowych. Jest to ważne zagadnienie zarówno dla Banku Centralnego, jak i banków komercyjnych, gdyż finansowanie rynku mieszkaniowego jest istotnym czynnikiem prowadzenia polityki pieniężnej oraz oceny poziomu ryzyka kredytowego.

Metodyka: Zastosowano metodę badania empirycznego opartego na modelu zbiorczej estymacji metodą najmniejszych kwadratów (OLS). Wykorzystano dane publikowane przez Główny Urząd Statystyczny oraz Centrum AMRON-SARFiN. Zagregowano je dla województw i kwartałów za okres 2010-2019.

Wyniki: Wynik analizy pozwala badaczom tego tematu oraz praktykom na identyfikację priorytetowych uwarunkowań cen nieruchomości mieszkaniowych w Polsce, którymi okazały się czynnik finansowy, to jest przychód (średnie zarobki miesięcznie), oraz demograficzny (nowe związki małżeńskie).

Oryginalność/wartość: Głównym walorem tych badań jest identyfikacja pozostałych analizowanych determinant, takich jak koszt budowy, stopy procentowe i podaż domów, jako nieistotnych determinant cen na polskim rynku nieruchomości w badanych okresie.

Słowa kluczowe: finansowanie nieruchomości mieszkaniowych, determinanty cenowe, bank