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The Identification of Seasonality in the Housing Market Using the X13-ARIMA-SEATS Model

Łukasz Mach

Opole University, Faculty of Economics, Opole, Poland

e-mail: lmach@uni.opole.pl

ORCID: 0000-0002-8200-4261

Ireneusz Dąbrowski

Warsaw School of Economics, Collegium of Management and Finance, Warszawa, Poland

e-mail: ireneusz.dabrowski@sgh.waw.pl

ORCID: 0000-0001-5353-7985

Daria Wotzka

Opole University of Technology, Faculty of Electrical Engineering, Automatic Control and Informatics, Opole, Poland

e-mail: d.wotzka@po.edu.pl

ORCID: 0000-0002-8861-7974

Paweł Frącz

Opole University, Faculty of Economics, Opole, Poland

e-mail: p.fracz@gmail.com

ORCID: 0000-0003-1677-6084

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Abstract

Aim: In the conducted research, profiles of seasonality in the housing market were determined, which provided an opportunity to answer two fundamental questions: what is the nature of harmonic variation in the seasonality and periodicity of the studied components of the construction process? what parameters of the ARIMA model optimally describe the construction market?

Methodology: In the conducted research, using the X13-ARIMA-SEATS model, seasonal decomposition was carried out in the various stages of the housing construction process.

Results: The research process conducted to identify seasonal fluctuations in the housing construction market showed that harmonic fluctuation profiles can be identified on an annual basis. An analysis of seasonal fluctuations was carried out for each of the three stages of the housing construction process, while also checking how these profiles function for Poland in general, and for individual investors, and for those building apartments for sale or to rent. The study showed that the market for real estate development activity differs in its seasonal characteristics from that of individual investors.

Implications and recommendations: The conclusions obtained from the research can provide support in the decision-making process, both from a macro and microeconomic perspective. Parameterisation of the occurring fluctuations, and taking them into account in the process of developing a forecast can provide decision-making rationale in the implementation of macroprudential and financial stability policies

Originality/Value: A novelty is in the demonstration that the residential real estate market in Poland shows different seasonal parameters, divided into the market of individual investors and investors who build apartments for sale or rent.

Keywords: seasonality, real estate market, X13-ARIMA-SEATS

1. Introduction

Housing construction is a vital component of the economy, significantly influencing its financial and macroeconomic stability. Understanding the housing construction market's impact on economic parameters is crucial, especially in identifying its components, including seasonality, to create and implement the appropriate market strategies. This research considers whether the phenomena under study concerning the housing construction process were characterised by harmonic changes over time. Identifying annual variability is key to analysing seasonal and periodic fluctuations in the housing construction market. The parameterisation of these fluctuations is critical in implementing macroprudential policy and maintaining financial stability, as it allows for the analysis of their varying courses and the optimal execution of economic policy.

The research employed a data analysis method based on the X13-ARIMA-SEATS models to establish seasonality profiles. This approach facilitated answering two fundamental questions: (1) What is the nature of harmonic variability in terms of seasonality and periodicity in the studied components of the construction process? (2) What parameters of the ARIMA (Autoregressive Integrated Moving Average) model optimally describe the construction market? The derived insights can inform decision-making from both macroeconomic and microeconomic perspectives. The study revealed that existing reports on Poland's residential real estate market lack full interpretative utility. These reports, produced by various institutions, typically focus on the aggregate market rather than distinguishing between segments pursued by individual investors and developers (building apartments for sale or to rent). The findings indicate that these market segments often exhibit distinct seasonal patterns, leading to different profiles of seasonal fluctuations and, consequently, different development scenarios.

2. The Origin of Harmonic Fluctuations in the Real Estate Market

Cycles and seasonal fluctuations in the real estate market play a crucial role in determining the market's development pace and are instrumental in both the successes and failures of market players. Participants in this market, comprising both demand and supply sides, increasingly recognise the strategic and decision-making importance of real estate cycle analyses, as outlined by Pyhrr et al. (1999). The concept of real estate cycles dates back to the 1930s, evolving from the domain of real estate land economics into a discipline integral to real estate investment, as noted by Hoyt (1933). Mitchell was one of the pioneers in establishing the theoretical basis of cyclical economic activity. In his seminal work "Business Cycles: The Problem and its Setting" (Mitchell, 1927), he detailed business cycles and their effects on various economic factors such as price volatility, currency value, bank health, savings, investment, and speculation, a perspective further explored by Sherman (2001). Mitchell's work, positioned between Marshall's "Fundamentals of Economics" (1890) and Keynes' "General Theory of Employment, Interest and Money" (1936), was a foundational contribution to economic cycles, popularising terms like oscillation, fluctuation, and rhythm, previously discussed by economists like Juglar and Marx (Friedman, 2018).

In the contemporary context, cyclicality remains a vital focus of scientific analysis in both theoretical and practical realms. Studies on long-term real estate price trends, such as those by Quigley (1999), examined the predictability of real estate market trends by fundamental economic factors and the potential impact of exogenous real estate price trends, including market bubbles, on economic fundamentals. Żelazowski's research (2017) offered an intriguing perspective on real estate market cycles in relation to business cycles, aiming to identify parallels and differences between housing market cycles and business cycles. Furthermore, the significance of research addressing the impact of economic or business variables on housing market cyclicality cannot be overstated. Studies exploring the influence of endogenous variables (Sommervoll et al., 2010), credit constraints (Kuang, 2014), purchase expectations (Lambertini et al., 2013), and financial intermediation (Yépez, 2018) on market cyclicality, contributed to a more nuanced understanding of the market dynamics. In the context of other studies exploring the cyclical nature of the real estate market, it suggested that cyclicality represents a structural characteristic of the housing market. This research suggests that observed cyclical fluctuations can be further influenced by the financial system, speculative behaviour, and interventionism (Coskun, 2022). It is imperative to note the significant body of literature addressing the application of quantitative methods in real estate market analysis. The latest trends in real estate market research, particularly the comparative analysis of recent publications utilising machine learning algorithms and their application in the real estate market, were extensively discussed in the studies by Breuer and Steininger (Breuer and Steununder, 2020). Apart from machine learning, compelling research in the real estate market domain is evident in the application of artificial intelligence (Kabaivanov and Markowska, 2021), specifically artificial neural networks (Peter et al., 2020; Yasnitsky et al., 2021), and genetic algorithms (Del Giudice et al., 2017; Sun 2019). In terms of real estate market analysis, it is crucial to acknowledge studies conducted employing the ARIMA method (Dong et al., 2020; Jadevicius et al., 2015; Tse, 1997).

3. Decomposition of Seasonal Fluctuations – Assumptions for X13-ARIMA-SEATS

To estimate the parameters of the ARIMA model, the X13-ARIMA-SEATS method was employed, which integrates the X-11-ARIMA method, accommodating calendar effects as described by Shiskin et al. (1967), with the SEATS technique for seasonal parameter selection, as outlined by Findley et al. (2016). Developed and utilised by the US Census Bureau, this approach combines statistical rigour with practical applicability. X13-ARIMA-SEATS is an advanced tool that integrates time series modelling with seasonal adjustment techniques. It is particularly useful when data are influenced by seasonality, trends, cyclical changes, and other disruptive factors, which are common in economic, financial, and meteorological data.

The X13-ARIMA-SEATS model provides more accurate forecasts and analyses as it takes into account both seasonality and irregularities in the data, which enables a better understanding and prediction of data patterns. This method offers flexibility in fitting the models to specific characteristics of time series. The ability to customise ARIMA parameters to the specifics of the data allows for more precise modelling and analysis. X13-ARIMA-SEATS effectively identifies and corrects anomalies and missing observations, which is crucial in dealing with time series that have irregularities or data gaps. One of the primary objectives of using X13-ARIMA-SEATS is the efficient identification and correction of seasonal influences, which is essential in analysing data that changes in cyclical periods.

The process of defining the parameters of the ARIMA model involved a three-phase iterative approach. The first phase, Identification, involved selecting a subset of potentially suitable models. The second phase, Estimation, was characterised by the effective utilisation of data to infer coefficients based on the tested model's suitability. The third phase, Diagnostic Checking, focused on evaluating the chosen model's fit with the data, identifying any discrepancies, and refining the model as necessary. It is important to note at the outset that the processes of identification and estimation often overlap. Therefore, it is common to estimate the parameters of a model that is more complex than that initially anticipated, to determine areas for possible simplification. The estimation procedure thus partially assumes the role of identification, as noted by Box et al. (2016). The identification process, being inherently imprecise, does not yield a precise formulation of the task. Graphical methods are especially valuable at this stage, however it is essential to understand that the initial identification only yields a sample class of models, which are then effectively fitted and rigorously tested.

The X13-ARIMA-SEATS approach combines two techniques: ARIMA model for time series forecasting and the SEATS (Signal Extraction in ARIMA Time Series) method for seasonal adjustment. The methodology is an enhancement of its predecessor, the X-12-ARIMA method, offering more advanced features and improved accuracy. The ARIMA model is central to this methodology. It is a class of models that explains a given time series based on its own past values, meaning it regresses the variable on its own lagged (past) values. The components of ARIMA are: (1) Autoregression (AR) – the model uses the relation between an observation and a number of lagged observations; (2) Integration (I) – involves differencing the raw observations to make the time series stationary (i.e. data values are replaced by the difference between the data values and a previous value); (3) Moving Average (MA) – exploits the relation between the observation and a residual error from a moving average model applied to lagged observations. The X-12-ARIMA is an earlier version of the seasonal adjustment software. The X13-ARIMA-SEATS method extends this by including enhancements for better diagnostics and the treatment of special days, trading day effects, and Easter effects. It decomposes a time series into seasonal, trend-cycle, and irregular components and allows for the modelling of seasonal patterns and calendar effects; SEATS is a procedure for extracting seasonal and trend components from a time series using an ARIMA model. This method provides a more robust and stable seasonal adjustment, especially for longer series. The integration of X-12-ARIMA and SEATS methodologies in X13-ARIMA-SEATS provides a powerful tool for seasonal adjustment. The combined method offers improved statistical accuracy in the presence of non-stationarity, it better handles outliers, missing values, and temporary changes. Furthermore, it provides extensive diagnostic features for model selection and validation and is capable of adjusting for both additive and multiplicative seasonality. This method necessitates a meticulous selection of model parameters and diagnostics, which entails iterative processes of model fitting and validation.

The general form of an ARIMA model is represented as ARIMA (*p, d, q*), where *p* – Order of the autoregressive part, *d* – Degree of first differencing involved, *q* – Order of the moving average part.

$$\left(1-\sum_{i=1}^{p}\varphi_i\,L^i)(1-L)^d\,X_t=\left(1+\sum_{i=1}^{q}\theta_i\,L^i\right)\varepsilon_t\right),$$

where: X_t – time series, φ_i – parameters of the autoregressive part, θ_i – parameters of the moving average part, *L* – lag operator, ε_t – error term.

After differencing the equation for the for the time series, Y_t is as follows:

$$Y_t' = c + \varphi_1 Y_{t-1}' + \ldots + \varphi_p Y_{t-p}' + \theta_1 \varepsilon_{t-1} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t.$$

The are two types of seasonal adjustments: additive and multiplicative. The first method assumes that the seasonal component remains constant over time. It is typically used when the seasonal fluctuations do not vary in proportion to the level of the series. The additive model can be defined as:

$$Yadd_t = T_t + S_t + C_t + E_t,$$

where: T_t – trend component, S_t – seasonal component, and C_t – cyclical component (longer-term fluctuations in the data), and E_t is the error, irregular or residual component.

Seasonal adjustment is performed by estimating seasonal component S_t and then subtracting it from original data $Yadd_t$ to obtain the seasonally adjusted data. This method is used when seasonal variations are proportional to the level of the time series; it is more appropriate for economic series that demonstrate proportional increases or decreases in the seasonal pattern.

The multiplicative model is defined as:

$$Ymult_t = T_t \times S_t \times C_t \times E_t.$$

In this model, the components are multiplied together instead of being added. Seasonal adjustment involves estimating seasonal component S_t and dividing original series $Ymult_t$ by this component.

The process of selecting the optimal model for identifying seasonal fluctuations and forecasting real estate market data is a comprehensive one, involving various statistical techniques and criteria. The authors applied autocorrelation and partial correlation analysis followed by model estimator and residual analyses. The autocorrelation analysis involves examining the correlation of a time series with its own past and future values, crucial for identifying patterns within the data, such as seasonality or trends. In the context of real estate, it might reveal how past market values or demand influence current trends. The partial correlation analysis goes a step further by isolating the correlation between two variables after removing the effects of other influencing variables. In real estate forecasting, this helps in understanding the direct relation between different market factors, controlling for other variables. The model estimators are the coefficients or parameters estimated by the model, which quantify the relation between the predictors and the response variable. Examining these estimators helps in understanding the impact of various factors on the real estate market. The residuals are the differences between the observed values and the values predicted by the model. Analysing residuals is essential for checking the model's accuracy and identifying any patterns missed by the model. Ideally, residuals should be random and not show any discernible pattern.

Moreover, the authors applied AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) for model accuracy estimation. The AIC is a widely used measure for model selection, which balances the model's fit with the number of parameters used, penalising over-complex models. A lower AIC value indicates a better model. The AIC is calculated using the formula:

$$\mathrm{AIC} = 2k - 2\ln(\hat{L}),$$

where: k – number of parameters in the statistical model, $\ln(\hat{L})$ – natural logarithm of the likelihood function L evaluated at the estimated values of the parameters. The likelihood function L measures how well the model explains the observed data.

Similarly to the AIC, the BIC also penalises complex models but does so more stringently, which is particularly useful in models with a large number of observations. Like with the AIC, a lower BIC suggests a better model. The BIC is calculated using the formula:

$$\mathrm{BIC} = \ln(n)k - 2\ln(\hat{L}),$$

where: n – number of observations, k – number of parameters in the model, $\ln(\hat{L})$ – natural logarithm of likelihood function L as with AIC.

The MATLAB programming environment toolbox, X-13ARIMA-SEATS, developed by Y. Lengwiler (Lengwiler, 2022), was used in the study. Among other things, this toolbox allows for the automated verification of the stationarity of time series and thus automatically transforms or not the analysed time series using a logarithmic function. In the task of selecting the optimal model, the TRAMO (Time series Regression with ARIMA noise, Missing observations, and Outliers) method, developed by Gómez and Maravall (Gómez and Maravall, 2001a, 2001b), was used. The TRAMO method is a well-known statistical technique for the analysis and forecasting of time series data. It employs ARIMA models to account for autocorrelations within the series, making it capable of handling a wide range of time series behaviour. It is equipped to deal with gaps in the data, and includes mechanisms for identifying and adjusting for outliers, which are data points that deviate significantly from the overall pattern of the time series and allows for incorporating regression components to model the effects of external variables or interventions that might influence the time series. The inclusion of external variables in the form of a regression model is in TRAMO represented as:

$$Y_t = \beta_t + \sum_{i=1}^{n} \beta_i \ X_{it} + u_t,$$

where: X_{it} – external variables or interventions, β_i – coefficients, and u_t represents the error term which is then modelled using an ARIMA process.

TRAMO identifies different types of outliers, such as Additive Outliers (AO), Level Shifts (LS), and Transitory Changes (TC). The impact of an outlier at time *t* can be represented as:

$$Y_\mathrm{t} = Y_\mathrm{t}' + w_\mathrm{t},$$

where: Y_t' – time series without the outlier, and w_t – outlier effect.

The computational engineering underlying this analysis was grounded in the X13-ARIMA-SEATS (statistical-mathematical) models, while the interpretation of the obtained results was conducted in the context of expert economic analysis.

4. Research Assumptions and Implementation of Research in the Process of Identifying Seasonal Fluctuations

The identification and analysis of seasonal fluctuations were conducted for the housing construction market, under the assumption that these fluctuations correlate with the stages of the housing construction process. According to the methodology defined by the Central Statistical Office (GUS), the stages of the housing construction process impacting the market under study include:

- Permits issued for the construction of apartments.
- Apartments whose construction has begun.
- New dwellings put into use.

For these variables, monthly data spanning over 17 years (from 2005 to 2022) were collected for Poland. This resulted in a total of 211 observations for each variable under study. The data used for analysis were taken from the publicly available database of the Bank of Local Data of the Polish Central Statistical Office, from the category Industry and Construction, the group Housing Construction (accessible at stat.gov.pl). To analyse the housing market comprehensively, the market structure was divided into three segments: the total market, apartments developed by individual investors, and apartments developed for sale or rent. However, due to their marginal quantitative significance, municipal, cooperative, social rental, and company housing were not included in this study. Dwellings constructed by individual investors were presumed to be structures built for their own needs. Conversely, apartments erected by investors for sale or rent were categorized as those built by professional companies (developers), primarily for resale or rental purposes. Refining these assumptions, one should also note that the housing market analysis was considered in terms of entities, i.e. as the market of users and the market of development activities. Later, applying a spatial criterion, the analysis was conducted on the national (nationwide) market.

The data were filtered using the mentioned X13-ARIMA-SEATS approach, then used to create box plots comparing the same months across different years, as presented in Figures 1 to 3. This approach allowed for a direct comparison of data from identical time periods, facilitating a clear understanding of any patterns or changes over time; in particular, mean values and percentiles, boundary values, and outliers were observed. The latter occur infrequently, although more often in winter than in summer.

Housing construction is a crucial component of the economy, significantly impacting on its financial and macroeconomic stability. Understanding the housing construction market's influence on economic parameters necessitates identifying its elements, including seasonality, which is vital for designing and executing appropriate market strategies. In modelling the components of the housing construction process, it was examined whether the phenomena under study were characterised by harmonic changes over time. The identification of annual variability enabled the analysis of seasonal and periodical fluctuations in the housing construction market. Parameterising these fluctuations is important for the implementation of macroprudential policies and maintaining financial stability, whilst analysing their slow and rapid variations facilitates the optimal execution of economic policies.

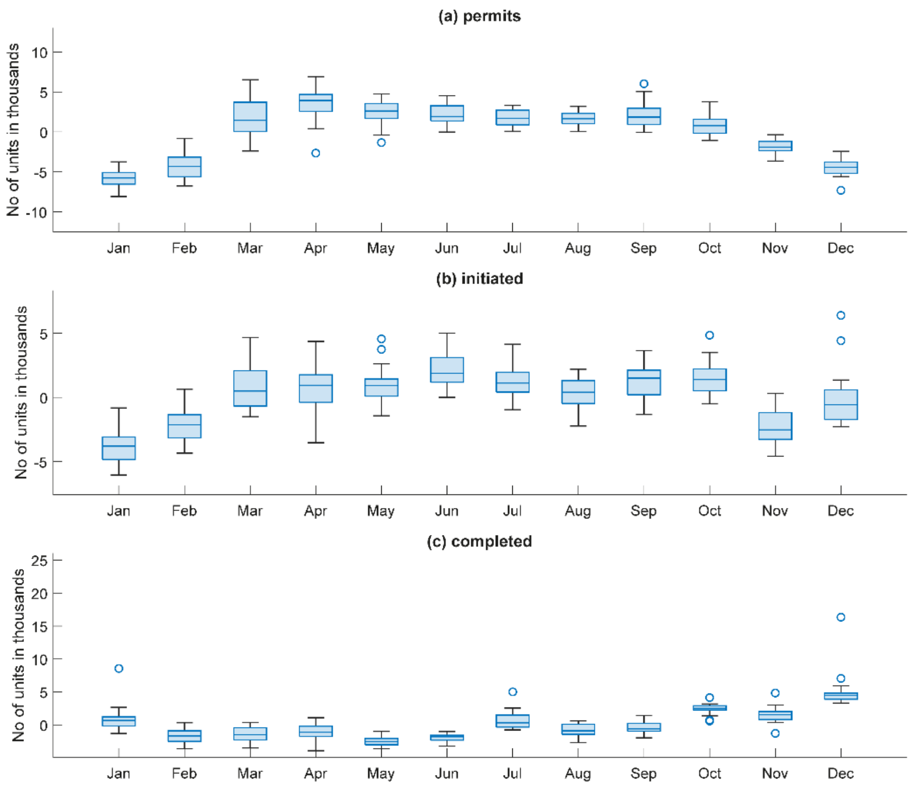

Fig. 1. Boxplots for seasonal profiles of the housing construction process – Poland, total

Source: own study.

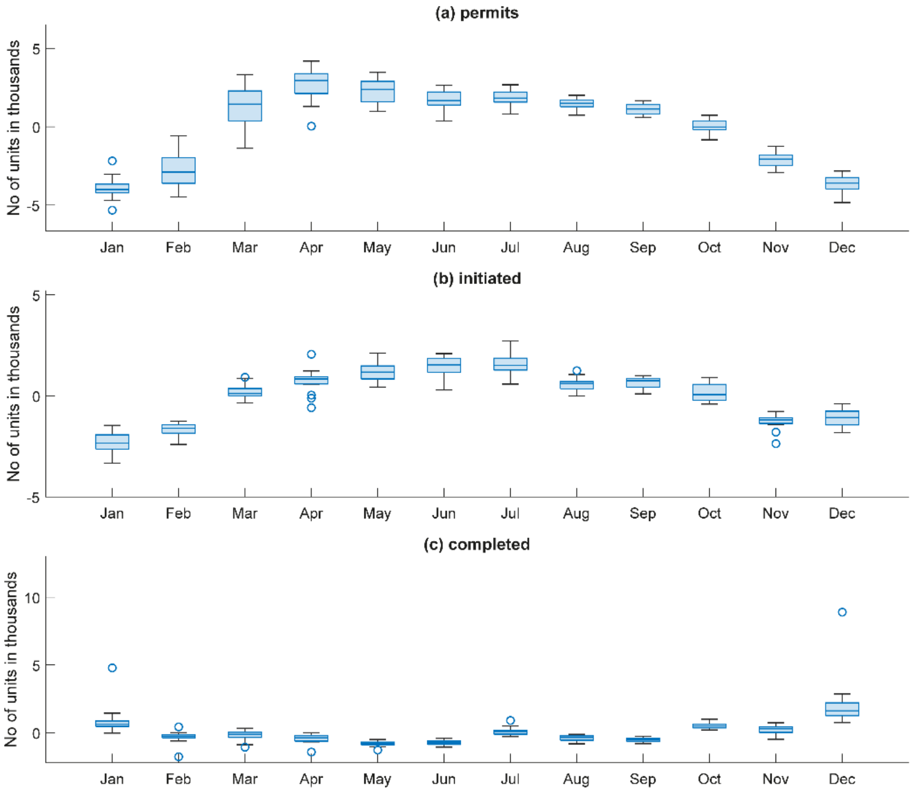

Fig. 2. Boxplots for seasonal profiles of the housing construction process – Poland, individually

Source: own study.

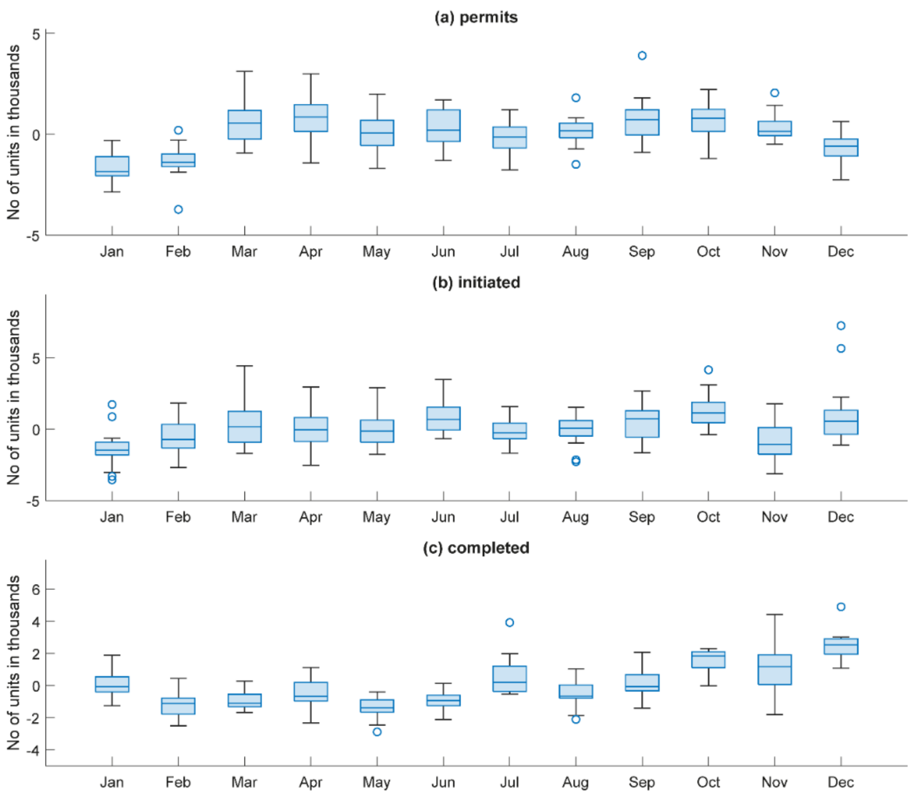

Fig. 3. Boxplots for seasonal profiles of the housing construction process – Poland, for sale or to rent

Source: own study.

The research employed a data analysis method based on the X13-ARIMA-SEATS models to determine seasonality profiles, addressing two fundamental questions: (1) What is the nature of harmonic variability in terms of seasonality and periodicity of the studied components of the construction process? (2) What parameters of the ARIMA model optimally describe the construction market? The insights derived from these questions can support decision-making processes from both macroeconomic and microeconomic perspectives. The study revealed that existing reports on Poland's residential real estate market lack full interpretative utility. These reports, produced by various institutions, often focus on the aggregate market without distinguishing between segments realised by individual investors and those by developers (building apartments for sale or to rent). The findings indicate that these market segments often exhibit distinct characteristics in terms of seasonal trends, resulting in differing profiles of seasonal fluctuations and, consequently, different development scenarios.

5. Identification and Analysis of Seasonal Fluctuations – Research Results

The identification and analysis of seasonal variations in this study are presented in two distinct parts. The first details the process of estimating the parameters of the parameterised ARIMA model utilising the X13-ARIMA-SEATS method, which includes an in-depth explanation of the model's setup, the selection of appropriate parameters, and the computational procedures involved. The second part focused on describing and interpreting the seasonal fluctuation profiles obtained from the ARIMA model. This section examines the patterns revealed by the analysis, discussing their implications and significance in the context of the housing construction market.

5.1. Estimation of ARIMA Model Parameters Using X13-ARIMA-SEATS

The presentation of the results obtained from the estimation of the ARIMA model was divided into two main stages. The first summarises the parameters of the estimated seasonal ARIMA (p, d, q) (P, D, Q) model. This includes detailing the type of time series transformation performed (either none or logarithmic) and a description of the nature of the identified seasonal fluctuations, which could be either additive or multiplicative. Table 1 provides a comprehensive summary of the data transformation and the nature of the seasonal adjustment applied. It also includes the parameters of the seasonal ARIMA model for all the studied stages of the housing construction process.

In the second stage, tests were conducted to determine the significance of the seasonal decomposition performed. To statistically verify the presence of stable seasonality in the considered time series, the authors calculated statistics using the F-test and the non-parametric Kruskal-Wallis test, which are part of the extended version of the Census Bureau X-11 and X-11Q program methodology. Additionally, the presence of seasonality in the moving component was ascertained using the F statistic. Table 2 presents a summary of these statistical values, along with the results of the hypothesis test for statistically significant seasonality. This includes either the confirmation or negation of the hypothesis, assuming the presence of identifiable seasonality. In Table 2, the following nomenclature was adopted:

- 'Numerical value of the statistic' (YES x%): This indicates the presence of seasonality at x% significance level, and implies that the statistical test has identified seasonality in the data with a confidence level corresponding to x%.
- 'Numerical value of the statistic' (NO y%): This denotes that there is no evidence of stable seasonality at y% significance level, meaning that the statistical test does not support the existence of seasonality in the data with a confidence level corresponding to y%.

Table 1. Summary of data transformation and seasonal adjustment for the whole country and the type of ARIMA model selected

Stages of housing construction	Transformation	Seasonal adjustment	Model ARIMA
Permits – total	Logarithm	multiplicative	(0 1 1)(0 1 1)
Permits – individual	Logarithm	multiplicative	(2 1 3)(0 1 1)
Permits – sell or rent	Logarithm	multiplicative	(1 1 1)(0 1 1)
Dwellings started – total	no transformation	additive	(0 1 1)(0 1 1)
Dwellings started–- individual	no transformation	additive	(0 1 1)(0 1 1)
Dwellings started – sell or rent	no transformation	additive	(1 1 1)(0 1 1)
Dwellings completed – total	Logarithm	multiplicative	(2 1 1)(0 1 1)
Dwellings completed – individual	Logarithm	multiplicative	(1 0 2)(0 1 1)
Dwellings completed – sell or rent	no transformation	additive	(0 1 1)(0 1 1)

Source: own study.

The values presented in these tables were calculated using the X11 method from the MATLAB toolbox. Within this toolbox, the parameters of the SEATS methodology facilitated the identification of stochastic seasonality, offering a single choice for the type of seasonal adjustment. For seasonal fluctuations that intensified with an increase in the series level, multiplicative fluctuations were identified, whilst for fluctuations where amplitudes remained independent of the series level, additive seasonality was assigned. Additionally, the SEATS methodology included statistical tests to determine whether the series should be modelled on the original data levels or on logarithmically transformed data. The types of transformation and seasonal adjustment as mentioned above are comprehensively documented in Table 1.

As a result of the analyses conducted on the data for Poland (as presented in Table 2), it was observed that identifiable seasonality is most likely absent only in the case of permits issued to developers. Moreover, the outcomes of the F and Kruskal-Wallis tests indicate the presence of stable seasonality at confidence levels of 0.1% and 1%, respectively, for all the considered variables, however the presence of a moving component varied across different time series. Specifically, the F test revealed no evidence of a moving component for the number of permits issued, as well as for the total number of constructions starts and those intended for sale.

Table 2. Numerical values of statistics for the existence of seasonality for the time series for the whole country

Stages of housing construction	The value of F statistics	The value of the Kruskal--Wallis statistic	The value of the F statistic for moving seasonality	Combined test for seasonality
Permits – total	29.63 (YES 0.1%)	114.62 (YES 1%)	0.894 (NO 5%)	YES
Permits – individual	118.5 (YES 0.1%)	165.12 (YES 1%)	3.04 (YES 1%)	YES
Permits – sell or rent	6.09 (YES 0.1%)	51.04 (YES 1%)	0.496 (NO 5%)	Probably NO
Dwellings started – total	62.21 (YES 0.1%)	139.18 (YES 1%)	1.128 (NO 5%)	YES
Dwellings started – individual	153.3 (YES 0.1%)	161.56 (YES 1%)	6.593 (YES 1%)	YES
Dwellings started – sell or rent	8.39 (YES 0.1%)	75.54 (YES 1%)	1.185 (NO 5%)	YES
Dwellings completed – total	41.89 (YES 0.1%)	147.61 (YES 1%)	2.195 (YES 1%)	YES
Dwellings completed – individual	21.40 (YES 0.1%)	144.00 (YES 1%)	3.001 (YES 1%)	YES
Dwellings completed – sell or rent	30.81 (YES 0.1%)	121.47 (YES 1%)	2.065 (YES 5%)	YES

Source: own study.

In summarising the results related to the identification of seasonality, particularly interpreting the combined test for seasonality, it should be noted that for developers constructing buildings for sale or to rent, no seasonality was observed during the initial stage of housing construction, in particular during the phase of obtaining building permits. This situation can be justified by the fact that these developers are predominantly large investment entities executing their projects with consistent intensity throughout the entire calendar year.

In addition to verifying the validity of the identified ARIMA models using the X13-ARIMA-SEATS tool, their predictive capabilities were also evaluated, which involved examining the progression of the studied time series, analysing the plots of the autocorrelation (ACR) and partial autocorrelation (PCR) functions, and assessing the conformity of the distribution of the residuals with the normal distribution.

5.2. Identify Annual Seasonality Profiles for the Housing Construction Process

The identification of annual seasonality profiles was carried out for three stages of the housing construction process. It was assumed that these stages could be identified by three key indicators: the number of building permits issued, the number of apartments whose construction has begun, and the number of apartments put into use. In addition, the analyses included total housing units and housing units built individually for sale or to rent.

For total housing (see Figure 1), in the case of permits issued for the construction of new apartments, it was observed that the first two and last two months of the year typically show the lowest values. Conversely, the values of the average seasonality profiles are positive in the remaining months. A similar pattern is evident in the seasonality profiles identified for total housing units whose construction has begun. However, the third stage of the housing construction process, which pertains to completed housing, exhibits a different seasonality profile. Unlike the previous two stages, where a relation between the seasonal profile and the time of year (months) can be discerned, this is not apparent for apartments put into use. The results indicate that in this third stage, where there is direct interaction between the buyer and the seller (the acquisition of the apartment), the seasons of the year that might influence the feasibility of housing construction projects do not significantly impact the seasonality profile. Similar patterns and characteristics in the identified profiles are also visible for apartments built by individual investors (see Figure 2).

For completed apartments built for sale or to rent, primarily realised through large-scale development projects, the profile of identified seasonality does not correlate with the seasons and their associated possibilities or limitations in the housing construction process (see Figure 3). This results in the first two phases of housing construction, as defined by permits issued for construction and housing whose construction has already begun, having distinctly different seasonal profile characteristics compared to housing in general and that by individual developers. Additionally, it is important to note that, regardless of the type of investor, the seasonal profiles for completed housing exhibit convergent characteristics.

Summarising the conducted research, it is possible to outline general conclusions as follows:

1. Nationwide, seasonal fluctuations were identified for each studied variable, which was confirmed by the ARIMA models. The parameters of these models are shown in Table 1. Additionally, for the variable “permits issued for the construction of new housing units”, the multiplicative nature of seasonal fluctuations was observed in each case considered. In contrast, for housing units where construction has already begun, seasonal fluctuations are additive.
2. On a nationwide basis, the seasonal parameters of the ARIMA model were consistent for each stage of housing construction, regardless of its purpose.
3. As a result of the statistical tests, significant seasonality was confirmed for each stage of the housing construction process for Poland as a whole.
4. The market for individual construction, and the market for constructions realised for sale or to rent are characterised by distinct profiles of seasonal fluctuations.

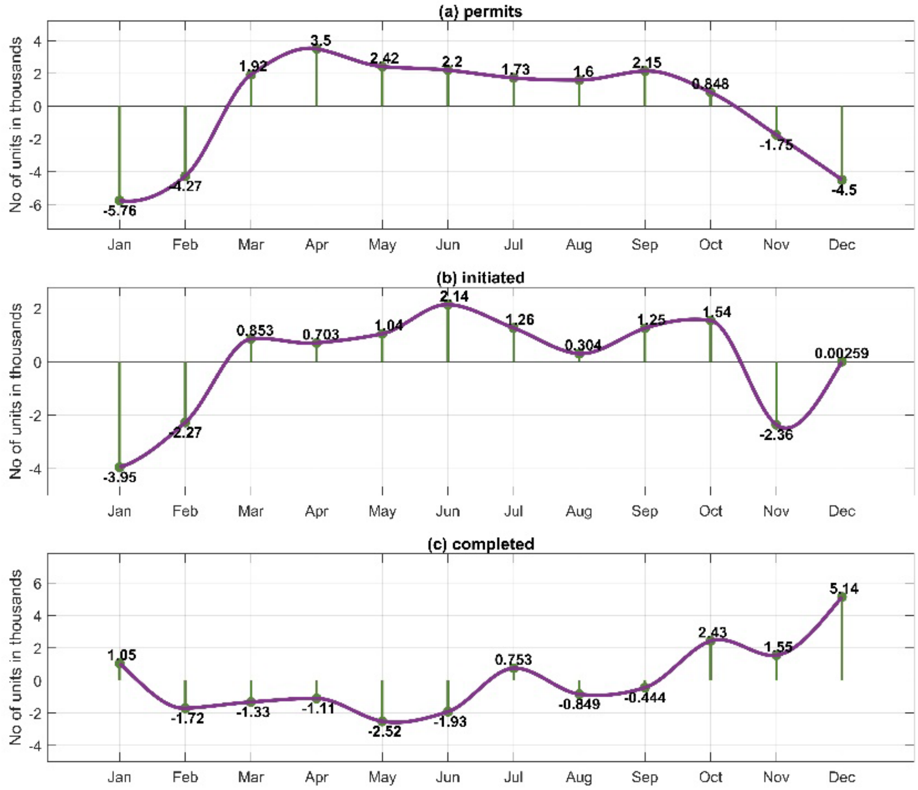

Fig. 4. Seasonal profiles of the housing construction process – Poland, total

Source: own study.

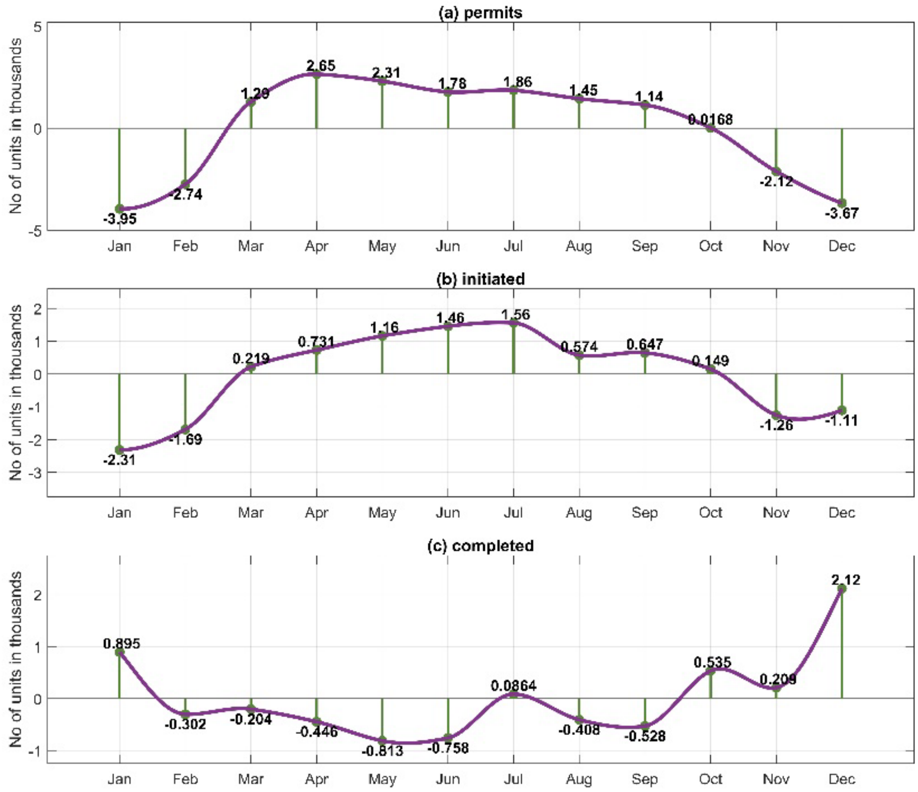

Fig. 5. Seasonal profiles of the housing construction process – Poland, individually

Source: own study.

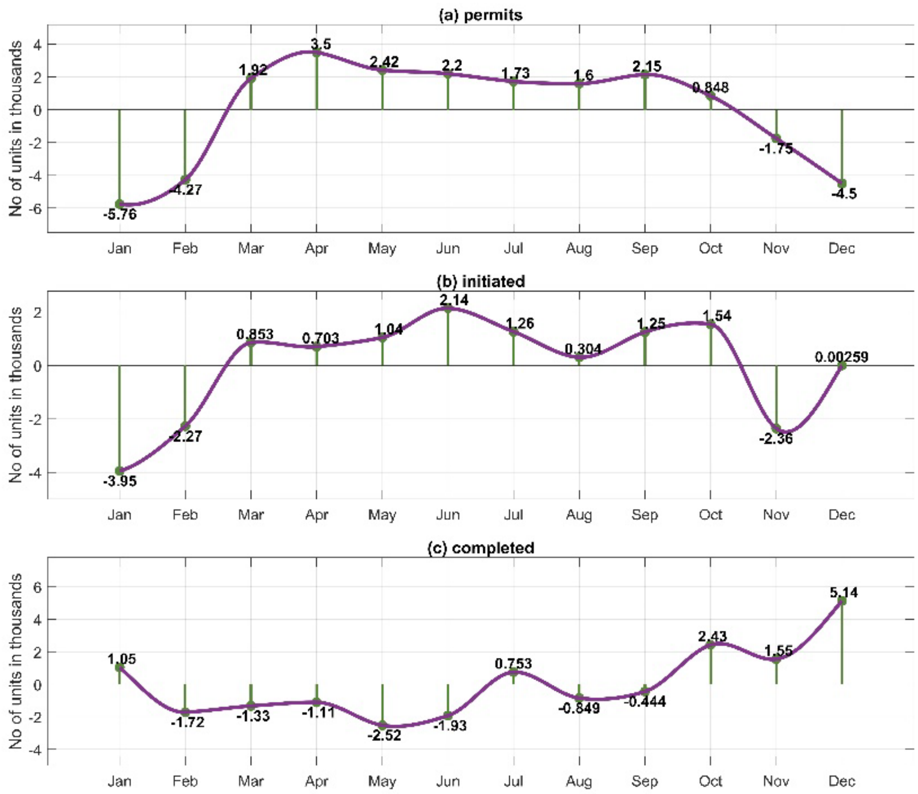

Fig. 6. Seasonal profiles of the housing construction process – Poland, for sale or rent

Source: own study.

The characteristics of seasonality profiles depicted in Figures 4 to 6 unequivocally demonstrate that investment activities in the residential construction market demonstrate distinct dynamics of changes when divided into the individual and developer markets. Examining the market of individual investors, it is notable that their investment activities are strongly influenced by the seasons. During the winter months, which are unfavourable from the perspective of the construction market, individual investors slow down their activity in the market, whereas for investors constructing homes for sale or to rent, typically large development enterprises with financial resources enabling the use of appropriate technology, the situation is different as they can operate independently of the weather conditions.

6. Discussion and Conclusions

The research process conducted to identify seasonal fluctuations in the housing construction market showed that harmonic fluctuation profiles can be identified annually. The analysis of seasonal fluctuations was carried out for each of the three stages of the housing construction process. This analysis also examined how these profiles develop in terms of Poland in general, for individual investors, and for those building apartments for sale or rent. The research showed that the market for developer activities differs in its seasonal characteristics from that of individual investors. This results in the fact that the development of market analyses in general, excluding individual and developer construction, lacks utilitarian aspects – which is how real estate market analysis and reports are often created in industry practice. In addition, the research made it possible to define the parameters of ARIMA models suitable for the process of identifying harmonic fluctuations. Models with well-defined parameters, obtained through estimation by the X13-ARIMA-SEATS method, can be a useful tool for extended analyses, such as constructing forecasts of this market and building scenarios for its development. The conclusions obtained from the research can provide support in the decision-making process, both from macroeconomic and microeconomic perspectives. Parameterisation of the occurring fluctuations and their inclusion in the development of a forecast can provide a decision-making rationale in the implementation of macroprudential and financial stability policies. Undoubtedly, the analysis of the obtained research results can be beneficial for entities operating within it, including both individual investors and those constructing homes for subsequent resale or rental.

References

Breuer, W., and Steininger, B. I. (2020). Recent Trends in Real Estate Research: A Comparison of Recent Working Papers and Publications Using Machine Learning Algorithms. *Journal of Business Economics*, *90*, 963-974. https://doi.org/10.1007/s11573-020-01005-w

Box, G. E. P., Jenkins, G. M., Reinsel, G. C., and Ljung, G. M. (2016). *Time Series Analysis. Forecasting and Control* (5th Edition). John Wiley & Sons.

Coskun, E. A. (2022). The Effect of Heuristics and Biases on Real Estate Valuation and Cyclicality. In M. d'Amato, Y. Coskun (Eds.), *Property Valuation and Market Cycle*. Springer. https://doi.org/10.1007/978-3-031-09450-7_8

Del Giudice, V., De Paola, P., and Forte, F. (2017). Genetic Algorithms for Real Estate Market Analysis. In O. Gervasi, et al., *Computational Science and Its Applications – ICCSA 2017* – 17th International Conference, Trieste, Italy, July 3-6, 2017, Proceedings, Part III. *Volume 10406 of* Lecture Notes in Computer Science*,* 467-477*,* Springer. https://doi.org/10.1007/ 978-3-319-62398-6_33

Dong, H., Guo, X., Reichgelt, H. et al. (2020). Predictive Power of ARIMA Models in Forecasting Equity Returns: A Sliding Window Method. *Journal of Asset Management*, *21*, 549-566. https://doi.org/10.1057/s41260-020-00184-z

Findley, D. F., Lytras, D. P., and Maravall, A. (2016), Illuminating ARIMA Model-based Seasonal Adjustment with Three Fundamental Seasonal Models. *SERIEs*, *7*, 11-52.

Friedman, W. A. (2018). *Wesley Mitchell's Business Cycles after 100 Years*. *New Perspectives on the History of Political Economy*. Springer International Publishing, https://doi.org/10.1007/978-3-319-58247-4_10

Gomez, V., and Maravall, A. (2001a). Automatic Modelling Methods for Univariate Series. In D. Peña, G. Tiao and R. Tsay, (Eds.), *A Course in Time Series Analysis, Wiley Series* (pp. 171-201). John Wiley & Sons.

Gomez, V., and Maravall, A. (2001b). Seasonal Adjustment and Signal Extraction in Economic Time Series. In D. Peña, G. Tiao, and R. Tsay (Eds.). *A Course in Time Series Analysis* (pp. 202-246). Wiley Series.

Hoyt, H. (1933). *One Hundred Years of Land Values in Chicago*. University of Chicago Press.

Jadevicius, A., and Huston, S. (2015). ARIMA Modelling of Lithuanian House Price Index. *International Journal of Housing Markets and Analysis*, *8*(1), 135-147. https://doi.org/10.1108/IJHMA-04-2014-0010

Kabaivanov, S., and Markovska, V. (2021). *Artificial Intelligence in Real Estate Market Analysis*. (AIP Conf. Proc. 2333, 030001).

Kuang, P. (2014). A Model of Housing and Credit Cycles with Imperfect Market Knowledge. *European Economic Review*, Elsevier, (70), 419-437. https://doi.org/10.1016/j.euroecorev.2014.06.013

Lambertini, L., Mendicino, C., and Punzi, M. T. (2013). Expectation-driven Cycles in the Housing Market: Evidence from Survey Data. *Journal of Financial Stability*, *9*(4), 518-529. https://doi.org/10.1016/j.jfs.2013.07.006

Lengwiler, Y. (2022). *X-13 Toolbox for Seasonal Filtering. MATLAB Central File Exchange*. MATLAB Central File Exchange, 29 September.

Mitchell, W. C. (1927). *Business Cycles: The Problem and Its Setting*. National Bureau of Economic Research, Incorporated.

Peter, N. J., Okagbue, H. I., Obasi, E. C. M., and Akinola, A. O. (2020). Review on the Application of Artificial Neural Networks in Real Estate Valuation. *International Journal of Advanced Trends in Computer Science and Engineering*, *9*(3), 2918-2925. https://doi.org/10.30534/ijatcse/2020/66932020

Pyhrr, S., Roulac, S., and Born, W. (1999). Real Estate Cycles and Their Strategic Implications for Investors and Portfolio Managers in the Global Economy. *Journal of Real Estate Research*, *18*(1), 7-68.

Quigley, J. M. (1999). Real Estate Prices and Economic Cycles*. International Real Estate Review*, *2*.

Sherman, H. (2001). The Business Cycle Theory of Wesley Mitchell. *Journal of Economic Issues*, Association for Evolutionary Economics, *35*(1), 85-97. https://doi.org/10.1080/00213624.2001.11506341

Shiskin, J., Young, A., and Musgrave, J. (1967). The X-11 Variant of the Census Method II Seasonal Adjustment Program, No. 15.

Sommervoll, D. E., Borgersen, T. A., and Wennemo, T. (2010). Endogenous Housing Market Cycles. *Journal of Banking and Finance*, *34*(3), 557-567. https://doi.org/10.1016/j.jbankfin.2009.08.021

Sun, Y. (2019). Real Estate Evaluation Model Based on Genetic Algorithm Optimized Neural Network. *Data Science Journal*, *18*(1), 36. https://doi.org/10.5334/dsj-2019-036

Tse, R. Y. C. (1997). An Application of the ARIMA Model to Real Estate Prices in Hong Kong. *Journal of Property Finance*, *8*(2), 152-163. https://doi.org/10.1108/09588689710167843

Yasnitsky, L. N., Yasnitsky, V. L., and Alekseev, A. O. (2021). The Complex Neural Network Model for Mass Appraisal and Scenario Forecasting of the Urban Real Estate Market Value That Adapts Itself to Space and Time. *Complexity*, *2021*, Article ID 5392170. https://doi.org/10.1155/2021/5392170

Yépez, C. A. (2018). Financial Intermediation and Real Estate Prices Impact on Business Cycles: A Bayesian Analysis. *North American Journal of Economics and Finance*, *45*, 138-160. https://doi.org/10.1016/j.najef.2018.02.006

Żelazowski, K. (2017). Housing Market Cycles in the Context of Business Cycles. *Real Estate Management and Valuation. De Gruyter Open Ltd*, *25*(3), 5-14. https://doi.org/10.1515/remav-2017-0017

Identyfikacja sezonowości na rynku mieszkaniowym przy użyciu modelu X13-ARIMA-SEATS

Streszczenie

Cel: W przeprowadzonych badaniach wyznaczono profile sezonowości na rynku mieszkaniowym, co dało możliwość odpowiedzi na dwa zasadnicze pytania: Jaki charakter ma harmoniczna zmienność sezonowości i okresowości badanych składowych procesu budowlanego? Jakie parametry modelu ARIMA optymalnie opisują rynek budowlany?

Metodyka: W przeprowadzonych badaniach, wykorzystując model X13-ARIMA-SEATS, dokonano dekompozycji sezonowej w poszczególnych etapach procesu budownictwa mieszkaniowego.

Wyniki: Proces badawczy przeprowadzony w celu identyfikacji wahań sezonowych na rynku budownictwa mieszkaniowego wykazał, że można zidentyfikować harmoniczne profile wahań w ujęciu rocznym. Analizę wahań sezonowych przeprowadzono dla każdego z trzech etapów procesu budowy mieszkań, sprawdzając jednocześnie, jak profile te kształtują się dla Polski ogółem oraz dla inwestorów indywidualnych i budujących mieszkania na sprzedaż lub wynajem. Badanie wykazało, że rynek działalności deweloperskiej różni się charakterystyką sezonową od rynku inwestorów indywidualnych.

Implikacje i rekomendacje: Wnioski uzyskane z badań mogą stanowić wsparcie w procesie podejmowania decyzji z perspektywy zarówno makro-, jak i mikroekonomicznej. Parametryzacja występujących wahań i uwzględnienie ich w procesie opracowywania prognozy może stanowić przesłankę decyzyjną w realizacji inwestycji deweloperskich.

Oryginalność/Wartość: Nowością jest wykazanie, że rynek nieruchomości mieszkaniowych w Polsce charakteryzuje się różnymi parametrami sezonowymi w podziale na rynek inwestorów indywidualnych oraz inwestorów wznoszących mieszkania na sprzedaż lub wynajem.

Słowa kluczowe: sezonowość, rynek nieruchomości, X13-ARIMA-SEATS