

Krzysztof Nowak

University of Rzeszów
e-mail: krnowak@ur.edu.pl
ORCID: 0000-0003-0543-1670

THE CAUSE-AND-EFFECT RELATIONSHIPS BETWEEN THE REAL ESTATE MARKET AND THE STOCK MARKET IN POLAND

DOI: 10.15611/pn.2020.8.10

JEL Classification: R15, R31

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Quote as: Nowak, K. (2020). The cause-and-effect relationships between the real estate market and the stock market in Poland. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, 64(8).

Abstract: The real estate market and the stock market are two elements of the financial market. The objective of the article is to verify if there can be established the cause-and-effect relationships between these two markets in Poland. In order to realise that goal the author verified if quotations of the WIG Real Estate index are affected by the mean transaction price of new apartments in 10 voivodeship cities, the number of apartments with the official permit to inhabit, as well as the value and number of new mortgage loans. The relationships between the WIG Real Estate and two main stock indexes quoted on the Warsaw Stock Exchange were also examined. Three Vector Auto-Regression models were formulated, and a Granger causality test was conducted. The study revealed that only lags of the number of apartments put into use did not affect the WIG Real Estate. Moreover, the time series of the mean transaction price of new apartments impacts most on the WIG Real Estate.

Keywords: real estate market, stock market, Vector Auto-Regression, Granger causality.

1. Introduction

The real estate market is part of the financial market, therefore it has to have natural connections to other elements of the latter market, among others to the stock market. The linkages between the stock market and the real estate market are subject to studies mainly in countries where Real Estate Investment Trusts operate. In Poland, legal provisions enabling the activity of the entities that could operate under the rules

such as REITs have not yet been introduced, therefore it may be vital to examine if the real estate and stock markets are linked, under Polish conditions. This area comprises the purpose of the study. In order to carry out the examination, the author decided to use the WIG Real Estate index quoted on the Warsaw Stock Exchange, which is a branch index, based on the companies operating in the real estate industry, thus one can say that it is on the borders of these two markets. The WIG Real Estate index quotation is affected by both groups of factors, i.e. those determining the economic situation in the real estate market as well as those influencing the state of the stock market. Therefore, this study attempts to answer the following questions:

1. Do the residential mean transaction prices, the number of apartments released for use, and the value and number of new mortgages impact with statistical significance on the WIG Real Estate index quotations?

2. Do the WIG and the WIG20 indexes quotation impact with statistical significance on the quotations of the WIG Real Estate index?

2. Literature review

The analysis of the literature indicates that the research material regarding the connection between the real estate market and the stock market is quite extensive. Most studies used the time series of major stock indexes, sub-real estate indexes, and the REITs indexes. In geographical terms, most publications cover the US and European markets, however recent studies predominantly concern the Asian markets. The studies were most often conducted to demonstrate the correlation, to analyse the causality-effect relationship of rates of return, and to a smaller extent were related to the interrelationships in liquidity on both markets. The approach that has definitely dominated literature in recent years when it comes to exploring the relationship between the stock market and the real estate market, is the Vector Auto-Regression approach, usually performed together with a Granger causality test.

Chen and Patel (1998), who used the aforementioned methodology, found a bilateral feedback effect between the prices of new houses in Taipei and the stock price index. Chen (2001) stated that in Taiwan equity prices Granger-caused real estate prices. Kallberg, Liu and Pasquariello (2002) based on data from eight developing Far Eastern countries, found that equity returns Granger-caused real estate returns and not the reverse. Subrahmanyam (2007) using liquidity, returns and trading activity data of the equity and the real estate securities markets in the USA, obtained results proving that non-REIT liquidity indicators Granger-caused those in the REIT market. Liu and Su (2010) found the existence of short-run unidirectional Granger causality running from the stock market to the real estate market in China. They also conducted the Error Correction Model, which indicated that in the long run, the price transmissions between the two markets are asymmetric. Clayton, Miller and Peng (2010) employed data regarding 114 housing markets in the USA and proved that house prices as well as turnover on housing markets are affected,

among others, by the stock market. Chan and Chang (2014) used the VAR approach to study interrelationships between the bond, real estate, and stock markets in China. They found out that stock returns affected real estate returns. Leung and Tang (2015) presented evidence of Granger causality between the number of IPOs and the real estate market in Chinese and Hong Kong markets.

Liow (2012) indicated that in Asia-Pacific economies, the correlations between the real estate market and the stock market were stronger at local level than at regional or global level. On the other hand, Liow and Schindler (2014) reported that in Asia-Pacific economies, the correlations were strongest at local level, while in some developed countries which were studied (the USA, four European countries, and Australia) the real estate and stock markets were more correlated at regional level. When it comes to causality, they found that there were periods of contemporaneous and lead-lag interactions in returns and volatility between the real estate and stock markets. However, the causality relationship appeared weaker and unstable mainly around the financial crisis. The last is unlikely when compared to what stylized facts suggest, since, as it is widely mentioned in the literature, "dependence between assets increases in periods of market turbulence" (Haas and Liu, 2018, p. 1). This was confirmed among others by Luchtenberg and Seiler (2014), who signalled that there was little evidence of the relationship between the real estate market and the stock market before the financial crisis, and in contrast, strong levels of integration after the delisting of Lehman Brothers.

In the subject literature, one can also find studies regarding non-linear dependency between the real estate and stock market. Okunev, Wilson and Zurbruegg (2000) after linear causality tests on USA data, concluded that with a unidirectional relationship from the real estate market to the stock market, however, was not consistent for all the sub-samples of the data. The non-linear causality test showed a strong unidirectional relationship running from the stock market to the real estate market. Okunev, Wilson and Zurbruegg (2002) repeated a similar study based on Australian data. Full-sample results supported bi-directional Granger causality between equity and real estate returns, however, sub-samples showed that changes within stock market prices influenced real estate market returns, but not vice versa. Moreover, in the case of non-linear causality tests, the results indicated a strong unidirectional relationship running from the stock market to the real estate market. Ding, Chong and Park (2014) examined non-linear quantile Granger causality relationships using Shanghai data. The results suggested a significant causal relationship between these two markets, especially in the tail quantile. Lou (2017) conducted similar research in the PIGS countries. The obtained results also indicated a significant causal relationship between these two markets, especially in the tail quantile.

In recent years there have been publications referring mainly to the impact of macroeconomic factors on the real estate market mechanism in Poland, e.g. Żelazowski (2011), Belej and Cellmer (2014). Nevertheless, one can also find articles that refer to relationships between the real estate and the stock markets in

Poland. Farinella et al. (Farinella, Graham, Markowski, and Schuhmann, 2013), employed linear regression and correlation analysis to seek relationships between residential property prices, rental prices in Warsaw and in the USA, as well as stock prices on the WSE and in the USA. They reported that stock returns had a positive impact on real estate prices but stock returns did not directly impact rental prices, and the correlation between real estate and stock markets in Poland was also low. Cellmer, Bełej and Cichulska (2019) concentrated on looking for Granger causality among secondary market housing prices and the number of new apartments put into use, with variables representing macroeconomic indicators and the WIG index. They found, among others, that the quotations of index WIG Granger-caused the housing transaction prices, while the housing transaction prices Granger-caused the number of apartments put into use.

As VAR models are most commonly used in literature the author decided to conduct the study using this approach.

3. Method and data

3.1. Method

The Vector Auto Regression approach assumes the construction of “multi-equation models, where every variable is explained by its lags and lags of the other explained variables” (Kusideł, 2000a, p. 100). Therefore, in the VAR model, the number of equations is equal to the number of variables used, so there is no a priori division into endogenous and exogenous variables (Wójcik, 2009). In addition, the VAR modelling assumptions also assume “no zero restrictions and no strict (priority in relation to modeling) economic theory on which the model is based” (Kusideł, 2000b, p. 10). In general, the model can take the following form (Kusideł, 2000a, p. 99):

$$x_t = A_1x_{t-1} + A_2x_{t-2} + \dots + A_kx_{t-k} + \Psi D_t + e_t$$

where: $t = 1, 2, \dots, T$, x_t – vector containing each of the n variables of the model, D_t – vectors of deterministic components e.g. intercept, linear trend, dummy variables, seasonal variables etc., Ψ – vector of variables D_t parameters exclusive of zero elements, A_i – matrices of parameters of lagged variables of vector x_t , without zero elements, e_t – vectors of stationary random disturbances.

The first step of the study was to assess the stationarity of the time series, conducted using the Augmented Dickey-Fuller test (ADF). The order of the lags of variables was determined individually for each model using lag order selection criteria (Akaike, Hannan-Quinn, Schwarz), limited to four lags, as the study was based on a quarterly time series. The author ran models with all the number of lags indicated by the order selection criteria and chose the final form of each of the models with the most explanatory variables being statistically significant, in equations with

the WIG Real Estate as a dependent variable. For each model, the author checked if the eigenvalues were inside the unit circle to satisfy the VAR stability condition. Finally, the models were subjected to verification using econometric tests. The author conducted the Lagrange multiplier test for autocorrelation within the models, as well as the Jarque-Bera test to verify if the residuals were normally distributed. Next, the Impulse Response Function charts showing the impact of particular variables on WIG Real Estate in 20 periods were presented. Last but not least, the study verified the relationships stated by the final models by checking if the variables that influence the fluctuations of the WIG Real Estate in the models also Granger-cause the fluctuations of the index. The study was conducted using Stata 13.

3.2. Data

Table 1 presents the data used in the study and descriptive statistics of the time series employed. The time series were based on quarterly periods from the second quarter of 2007, i.e. the first quarter of quotations of the WIG Real Estate index, to the first quarter of 2020. In the study, the author used time series formatted into the first differences of natural logarithms.

The time series of the WIG Real Estate, WIG and WIG20 (Biznesradar, 2020) indexes represent quotations at the closure of the last business day in each quarter. The WIG Real Estate is an industry index composed of companies listed in the WIG index, qualified for the real estate sector. It is an income index and therefore takes into account the prices of the shares contained therein, but also dividends and pre-emptive rights income (GPW, 2020a). The index consists of 26 companies¹. The fact that companies included in the WIG Real Estate index are part of the WIG index, in itself causes that one can look for the interdependence between these two indexes. The economic situation of the broad market should also ‘spread’ into smaller indexes, including industry indexes. Therefore, one variable that may significantly influence the fluctuations of the WIG Real Estate index was based on the WIG index’s time series quotations. The WIG index is the oldest index listed on the WSE which includes all companies listed on the main WSE market that meet the basic criteria for participation in indexes. The WIG index has an income index nature (GPW, 2020a). The stock index which can be defined as the main index on the WSE is, however, the WIG20. It is a typical blue chips index, based on the twenty largest and most liquid companies in the WSE. The WIG20 is a price-type index, i.e. only the prices of the transactions concluded are taken into consideration for its calculation, while other revenues are not taken into account (GPW, 2020a). The WIG20 index is highly popular among foreign investors and forms the basis for the most variable futures contracts² on the WSE.

¹ As of 21.07.2020.

² Since 2015, foreign investors have been responsible for more than half of the stock market turnover on the WSE (GPW, 2020b).

Table 1. Name, definition and descriptive statistics of time series employed

Name of the variable	Time series (unit)	Min.	Max.	Avg.	Med.	SD
WIGRE	Quotations of the WIG Real Estate index at closure of last business day in each quarter (index points)	1 237	6 463	2 153	1 923	1 039
WIG	Quotations of the WIG index at closure of last business day in each quarter (index points)	24 036	66 078	48 879	48 874	9 281
WIG20	Quotations of the WIG20 index at closure of last business day in each quarter (index points)	1 512	3 759	2 347	2 314	433
TP10	Mean of transaction prices of 1 sq m. of new residential premises in each quarter, weighted with the market stock of housing in ten Polish cities (PLN/sq m.)	3 923	6 260	4 874	4 738	426
RPC	Completed residential premises with permit to make use of in each quarter (number of residential premises)	25 849	61 769	39 836	37 968	8 104
VoML	Value of newly granted mortgage loans in each quarter (mln PLN)	7 609	16 874	11 663	10 937	2 495
NoML	Number of newly granted mortgage loans in each quarter	37 941	88 372	53 311	50 419	11 360

Note: time series of TP10 refer to residential premises in the following cities: Białystok, Bydgoszcz, Katowice, Kielce, Lublin, Olsztyn, Opole, Rzeszów, Szczecin, Zielona Góra.

Source: own study.

Due to its construction, the industry indexes should also have a certain characteristic that distinguishes them from the broad stock market, reflecting the features of different sectors, such as seasonality, specific types of risks, etc. Given the above, the author also has taken into account the time series of data that can be described as fundamental real estate market factors influencing the WIG Real Estate index. In that context, the study used quarterly time series of the mean of transaction prices of 1 sq. m. of new residential premises. The mean price reported by the National Bank of Poland (NBP, 2020) is weighted with the residential market stock and calculated for ten Polish cities which are capitals of voivodeships, which can be considered as second-tier residential markets³. The study also used the time series of the number of residential premises with a permit to be released for use. The author decided to use the time series as it comprises the effect of the activity of development companies and is directly linked with their financial results, while for example for building permits this is not always

³ In section 5 “Discussion and conclusions” one can follow a discussion regarding this time series.

the case. The quarterly time series is reported by the Polish Central Statistical Office (BDL, 2020). Changes in the price of new apartments and the number of apartments put into use ('production volume' of the housing sector) are key indicators of assessing the condition of the residential market. On the one hand, they should translate into decisions for development companies to undertake new investment projects and, on the other, they have impact on the income of developers, real estate agents, and other real estate market participants. Due of the above, the two variables should allow for assessing the impact of the housing market condition on the stock market valuation of real estate companies, and therefore also on the WIG Real Estate index.

The residential market is directly linked with the mortgage market. The value of mortgages granted reflects the state of the housing market. At the same time, a well-functioning mortgage market is a requirement for the development of the housing market. Hence, the author also employed the quarterly time series of values and the number of newly granted mortgages. The data comes from AMRON-SARFiN reports published by the Association of Polish Banks (ZBP, 2020).

4. Results

The author used the time series transformed into the first differences of LN⁴, and decided to choose the final form of each model, firstly, with a number of lags indicated by at least one lag order selection criterion⁵, and secondly, for which the number of statistically significant variables in the equation with WIG Real Estate as the dependent variable, is the highest. The main goal of the article is to verify which variables significantly affect WIG Real Estate, which is why the following part of the paper focused on the equations in each of the models in which WIG Real Estate plays the role of the dependent variable.

Models 1 to 3 are presented in Table 2. In Model 1, five lags of four variables statistically significantly explain the fluctuations of WIG Real Estate. In the case of Model 2, six lags of variables are statistically significant, while in Model 3 five lags of four variables are significant. In all the models only lags of the variable representing the time series of completed residential premises with a permit to release for use, did not significantly influence WIG Real Estate. The highest absolute value of the coefficient of significant variables for all three models occurs in the case of lag 4 of LNTP10C. Changes in the mean transaction price, therefore, have a stronger impact on WIG Real Estate fluctuations than other variables. Interestingly, the coefficient is negative. This is also the case for all the statistically significant lags of the other variables, except for the lags of LNWIGREC. It is also worth noting that a certain regularity can be found when it comes to statistically significant orders of the lags of

⁴ Due to limited space the results of the ADF test were not included in the text; it can be provided upon request.

⁵ Due to limited space the results of the lag order selection criteria were not included in the text; it can be provided upon request.

the explanatory variables, which for some variables are generally the same or similar in all three models; R^2 in the three models stays at around 60%.

Table 2. Equations in which WIG Real Estate is a dependent variable, Models 1 to 3

Independent variables		Model 1		Model 2		Model 3	
		coefficient	<i>z</i>	coefficient	<i>z</i>	coefficient	<i>z</i>
LNWIGREC	Lag1	0.307	1.63	0.335	1.81***	0.213	1.25
	Lag2	0.441	2.29**	0.413	2.23**	0.371	2.13**
	Lag3	-0.013	-0.06	-0.033	-0.16	0.068	0.36
	Lag4	-0.059	-0.26	-0.024	-0.12	-0.132	-0.63
LNWIGC	Lag1	-0.343	-1.23	-0.425	-1.55	-	-
	Lag2	-0.624	-2.12**	-0.505	-1.77***	-	-
	Lag3	0.298	0.99	0.305	1.10	-	-
	Lag4	-0.599	-2.31**	-0.592	-2.32**	-	-
LNWIG20C	Lag1	-	-	-	-	-0.214	-0.90
	Lag2	-	-	-	-	-0.537	-2.16**
	Lag3	-	-	-	-	0.180	0.70
	Lag4	-	-	-	-	-0.490	-2.20**
LNTP10C	Lag1	1.344	1.15	1.137	1.03	1.444	1.19
	Lag2	0.503	0.48	0.461	0.46	0.726	0.66
	Lag3	-0.619	-0.55	-0.515	-0.48	-0.378	-0.33
	Lag4	-2.030	-2.90*	-2.288	-3.41*	-1.810	-2.58**
LNRPCC	Lag1	0.197	1.04	0.233	1.29	0.171	0.90
	Lag2	-0.091	-0.51	-0.093	-0.56	-0.016	-0.09
	Lag3	-0.056	-0.30	0.051	0.29	-0.060	-0.32
	Lag4	-0.058	-0.33	-0.058	-0.35	-0.002	-0.01
LNVoMLC	Lag1	-0.072	-0.32	-	-	-0.086	-0.37
	Lag2	-0.537	-2.52**	-	-	-0.561	-2.55**
	Lag3	-0.093	-0.37	-	-	-0.074	-0.28
	Lag4	0.273	1.36	-	-	0.249	1.22
LNNoMLC	Lag1	-	-	-0.198	-0.93	-	-
	Lag2	-	-	-0.442	-2.05**	-	-
	Lag3	-	-	-0.217	-0.87	-	-
	Lag4	-	-	0.303	1.52	-	-
R^2		0.6051		0.6203		0.5934	

Note: * $p < 0.01$; ** $p < 0.05$; *** $p < 0.1$. LN at the beginning of the variables' names stands for logarithm, C at the end of the name stands for first difference.

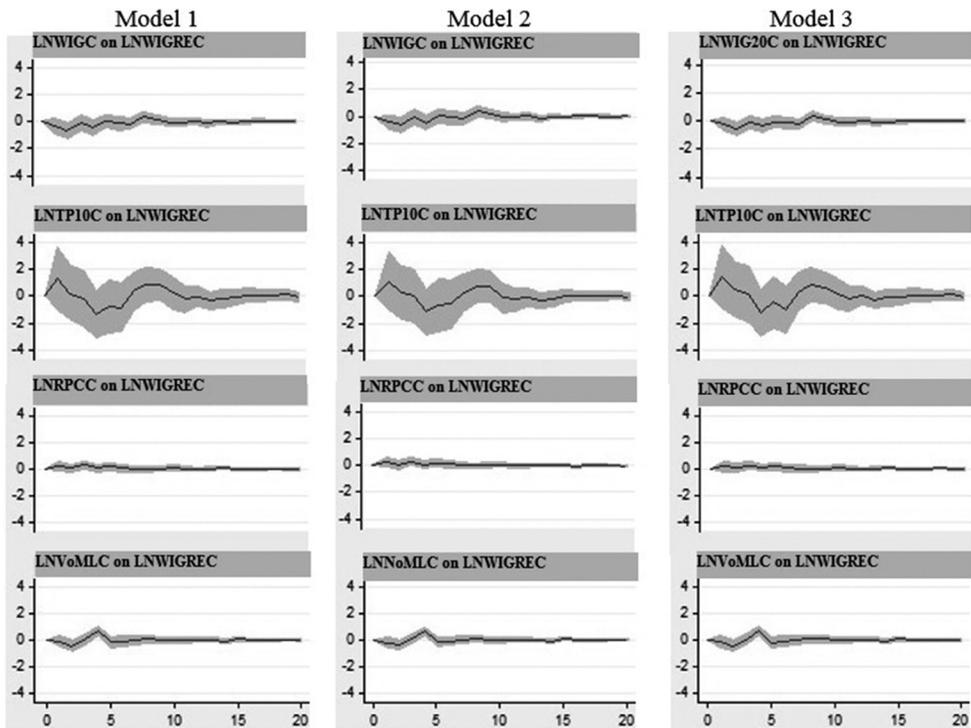
Source: own study.

The results of the Lagrange multiplier test for autocorrelation and the Jarque-Bera test for the normal distribution are reported in the Appendix, and in Tables A.1-A.2, respectively. As far as the Lagrange multiplier test is concerned, the null hypothesis of no autocorrelation can be accepted at $p = 0.1$, for each of the models. The outcomes of the Jarque-Bera test for Models 1 to 3 insist that the null hypothesis of the normal distribution of residuals shall be accepted, however, at a different p value. In the VAR approach, all the eigenvalues should be lower than one, which is “a basic condition for the practical use of the VAR model, if it is not met, that means that responses for impulse will form non-stationary processes with an explosive course” (Kufel, 2013, p. 170). In the case of all three models, all the eigenvalues lie inside the unit circle, according to which VAR satisfies stability condition⁶.

VAR enables the formulation of the impulse response function, to determine how implementing to the system shock of a selected explanatory variable affects the selected dependent variable over subsequent periods. Figure 1 shows the impulse response functions in 20 quarters, of the WIG Real Estate reaction to the impulse of one standard deviation of particular variables. The response of LN WigREC to the impulse of LN WigGC as well as LN Wig20C in all three models is rather modest. LN WigREC fluctuates slightly below zero over the first few periods, then increases and exceeds this level. Before the tenth quarter since the shock, the LN WigREC chart smooths to the horizontal line at zero. The response of LN WigREC in all six models is most evident to the impulse of LN TP10C. Already in the second period since the occurrence of the shock, WIG Real Estate quotations reach the maximum level. Around the fifth period, LN WigREC falls sharply, which is followed by an equally sharp increase, however, it does not reach the level of the first rise. In the following quarters, changes in WIG Real Estate quotations gradually decline and after ten periods cease to show deviations of significant magnitude. The range of WIG Real Estate responses to LN VoMLC and LN NoMLC shocks is similar to responses to shocks from the WIG and WIG20 indexes. Initially, LN WigREC experiences a slight drop below zero, with a one-off peak in the fourth quarter. Later, the graph of LN WigREC stabilizes around zero and does not exhibit major fluctuations. There is basically a lack of response of LN WigREC as far as shock of LN RPCC in Models 1 to 3 is concerned.

The author examined Granger causality between LN WigREC and the other variables employed in the models. The results are presented in Table 3. Most explanatory variables in the models do Granger-cause variations of the WIG Real Estate, however at a different p value, ranging from 0.01 to 0.05. The exception is the variable which represents completed residential premises with a permit to release for use. Such a result was expected, as the same conclusion comes from the analysis of the models in Table 2.

⁶ Due to limited space the results of eigenvalue stability condition were not included in the text; it can be provided upon request.



Note: the grey area represents 95% confidence interval.

Fig. 1. Impulse response function of LN WigREC on one standard deviation impulse of variables from Models 1 to 3

Source: own study.

Table 3. Results of the Granger-causality Wald test of the variables used in Models 1 to 3 (the causality of each of individual variables on LN WigREC)

Independent variable	Model 1		Model 2		Model 3	
	chi ²	Prob > chi ²	chi ²	Prob > chi ²	chi ²	Prob > chi ²
LN WigC	14.265	0.006*	13.536	0.009*	–	–
LN Wig20C	–	–	–	–	12.499	0.014**
LN TP10C	12.639	0.013**	15.615	0.004*	10.285	0.036**
LN RPCC	5.6632	0.226	5.4601	0.243	4.0974	0.393
LN VoMLC	14.774	0.005*	–	–	14.367	0.006*
LNN oMLC	–	–	17.249	0.002*	–	–
All	50.437	0.000*	54.342	0.000*	47.629	0.000*

Note: * $p < 0.01$; ** $p < 0.05$; *** $p < 0.1$.

Source: own study.

5. Discussion and conclusions

In the course of this study it was shown that there is a statistically significant causality relationship between the WIG Real Estate quotation and new apartments mean prices, the value and number of new mortgages, as well as the quotation of the WIG and WIG20 indexes. However, no such dependency was found in terms of the variable representing the number of completed residential premises with a permit to release for use. Such a result, in the author's opinion, could be due to the specificity of the Polish residential market, where a large part of the supply of new apartments finds owners even before putting them into use. The process of commercialization of residential development projects begins at an early stage of their physical construction. Taking into consideration the long investment process, it can be concluded that sold apartments are included in the financial results of development companies, and thus also anticipated by stock investors and reflected in the changes in the quotation of the WIG Real Estate index, earlier than four quarters before they are put into use.

Furthermore, it should be mentioned that while formulating VAR models the author used the time series of the average of the transaction prices of new residential premises, in ten as well as in seven Polish cities. The latter can be described as the main residential markets in Poland. Nevertheless, in the case of the models including the variable based on the mean of the transaction prices in seven cities, the study obtained poor econometric results – the variable was often not statistically significant, and furthermore, fewer other variables were statistically significant and fewer variables Granger-caused fluctuations of the WIG Real Estate. This may be slightly surprising, as most companies included in the WIG Real Estate index are present primarily in the largest residential markets in the country (such as Warsaw, Cracow, Lodz, Wroclaw, Poznan, Trojmiasto, i.e. Gdansk, Gdynia and Sopot). However, the main residential markets tend to be more competitive. On such markets, a vast number of sold residential premises can come from development companies which are not quoted on the WSE. In the case of such companies, the sold residential premises and their prices are included in the data reported by the Polish Central Statistical Office and the National Bank of Poland. On the other hand, the financial results of such companies do not affect the fluctuations of WIG Real Estate, which may be a cause for the lack of anticipated linkages. Therefore, the author decided to drop the models which included residential price variable based on the main housing markets, in favour of the models based on second-tier cities. The verification of the direct causes of the worse econometric results for models with the time series of average transaction prices for the main housing markets, may be the proper direction for the future studies.

Among the variables used, the strongest impact on WIG Real Estate is attributed to the mean of transaction prices of new residential premises in second-tier residential markets. In all three models, the positive influence on WIG Real Estate is represented

only by lags of the dependent variable itself. For all other variables, the coefficients are negative. Concerning the WIG and WIG20 indexes, this may indicate that the peaks and downturns in the stock and real estate markets are 'passing' each other, they are not contemporaneous. The negative coefficients are far more surprising when it comes to the factors that can be described as fundamental in relation to the real estate market, i.e. the mean of the transaction prices and the value and number of new mortgages. This may indicate that investors tend to terminate investments in real estate shares during the best economic conditions on the real estate market. At the same time, this suggests that investors are more prone to invest capital in real estate stock during a market downturn. This may result from the combination of prosperity on the real estate market with high costs of development projects. In such a scenario when the housing market is approaching the peak levels in a given business cycle, typically higher revenues for developers are accompanied by higher operating costs associated with rising labour costs, costs of construction materials, as well as higher prices of investment land. This may mean that, along with increasing sales of apartments at higher prices, the profits of companies operating in the housing market may decrease due to relatively high operating costs. This situation, noted by the investors, may lead to less interest in the entire industry, and thus directly cause a decrease in the quotation prices of companies listed in the WIG Real Estate index. Nevertheless, such an explanation seems appropriate in the short term. As for the long term, one could assume that the relationships between residential prices, the number and value of mortgages, and the valuation of companies operating in the real estate sector, should nevertheless be positive.

The main limitation of the study is the limited range of time series. The study was conducted on the time series ending in the first quarter of 2020, when in many countries of the world, including Poland, the lockdown related to COVID-19 began. It has to be stressed that in March 2020 the impact of COVID-19 was already clearly visible on the stock market, while it was not yet reflected on the real estate market. This fact certainly influenced to some extent, the obtained results. The study also limited the number of lags to four. However, the real estate market is more distant from the concept of a perfect market than the stock market. Demand and supply adjustments in this market are much slower, mostly due to the long investment process, legal and administrative barriers, etc. which may imply the need to use a higher order of lags. Yet, in the case of the VAR models consisting of more than two variables, given the time span of time series, this significantly reduces the number of the degree of freedom.

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ZALEŻNOŚCI PRZYCZYNOWO-SKUTKOWE MIĘDZY RYNKIEM NIERUCHOMOŚCI ORAZ RYNKIEM GIEŁDOWYM W POLSCE

Streszczenie: Rynek nieruchomości i giełda to dwa elementy rynku finansowego. Celem badawczym artykułu jest odpowiedź na pytanie, czy w polskich warunkach można mówić o zależności przyczynowo-skutkowej między tymi dwoma rynkami. W tym celu zweryfikowano, czy występuje istotna statystycznie zależność między indeksem WIG Nieruchomości oraz średnimi cenami transakcyjnymi nowych mieszkań w 10 miastach wojewódzkich, liczbą mieszkań oddanych do użytkowania oraz wartością i liczbą nowych kredytów hipotecznych. Ponadto zbadano, czy notowania indeksu WIG Nieruchomości są zależne od głównych indeksów giełdowych notowanych na Giełdzie Papierów Wartościowych w Warszawie. Sformułowano trzy modele autoregresji wektorowej, przeprowadzono również test przyczynowości Grangera. Uzyskane wyniki wskazują, iż jedynie liczba mieszkań oddanych do użytkowania nie wpływa na WIG Nieruchomości. Największy wpływ na notowania indeksu WIG Nieruchomości przejawiają średnie ceny transakcyjne nowych mieszkań.

Słowa kluczowe: rynek nieruchomości, rynek giełdowy, autoregresja wektorowa, przyczynowość w sensie Grangera.

Appendix

Table A.1. Results of the Lagrange-multiplier test for autocorrelation in residuals

Lag	Model 1		Model 2		Model 3	
	chi ²	Prob > chi ²	chi ²	Prob > chi ²	chi ²	Prob > chi ²
1	23.3861	0.55503***	23.2400	0.56355***	22.5056	0.60641***
2	28.4569	0.28725***	29.5686	0.24085***	24.9314	0.46622***
3	24.2876	0.50281***	24.3927	0.49679***	22.2501	0.62126***
4	20.8021	0.70359***	20.4213	0.72439***	21.6055	0.65841***

Note: no autocorrelation at lag order at * $p > 0.01$; ** $p > 0.05$; *** $p > 0.1$.

Source: own study.

Table A.2. Results of the Jarque-Bera test for normal distribution

Equation (dependent variable)	Model 1		Model 2		Model 3	
	chi ²	Prob > chi ²	chi ²	Prob > chi ²	chi ²	Prob > chi ²
LNWIGREC	5.782	0.05552**	6.445	0.03986*	6.248	0.04398*
LNWIGC	0.375	0.82910***	0.093	0.95436***	–	–
LNWIG20C	–	–	–	–	0.066	0.96772***
LNTPI0C	1.414	0.49308***	2.341	0.31029***	1.162	0.55946***
LNRPCC	0.576	0.74985***	0.584	0.74680***	0.023	0.98842***
LNVoMLC	5.438	0.06593**	–	–	5.303	0.07055**
LNNNoMLC	–	–	6.664	0.03572*	–	–
All	13.585	0.19278***	16.127	0.09605**	12.801	0.23499***

Note: normal distribution at * $p > 0.01$; ** $p > 0.05$; *** $p > 0.1$.

Source: own study.