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Convergence of residential property prices in the Szczecin agglomeration in the context of the COVID-19 pandemic

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Abstract

The outbreak of the COVID-19 pandemic has left a great mark on all of humanity. In addition to the immediate threat to health and life, the virus in a way also infected other spheres of human life. The lockdowns, which lasted for many weeks, had a very big impact on various sectors of the economy. Most of them experienced a severe slowdown or recession. However, there were areas that benefited from the fact that the people in many countries stayed at home and worked remotely. Examples of such areas include the computer and tablets market, online stores, and delivery companies. This proves that even in difficult circumstances like a pandemic, we are not facing a total global recession. In such a context, it is worth looking at the impact of the COVID-19 pandemic on the real estate market. This area of the economy can experience the impact of the virus in different ways. On the one hand, a general increase in global uncertainty can cause certain investment projects to freeze or be abandoned. Lockdowns cause difficulties in accessing workers at construction sites. Populations losing their jobs during a pandemic have difficulty paying rent or mortgage payments. On the other hand, rising inflation and low interest rates on bonds and bank deposits may encourage people to protect their savings by buying property. Remote working increases the demand for larger apartments that need to serve as offices in addition to residential functions. Remote work also means not having to commute to workplaces, which may encourage people to move to cheaper locations without having to give up a well-paying job in a larger but also more expensive city. These two groups of impulses are contradictory and may have a completely different impact on the shape of the real estate market understood as the structure of prices and the number of transactions concluded. The study is part of a broader research effort to assess the impact of the COVID-19 pandemic on various areas of the economy. Previous research conducted in the Szczecin agglomeration proved the existence of the price divergence phenomenon. The main city of the agglomeration showed a tendency to pull in the economic potential from the region, which translated into a faster increase in real estate prices in the capital of the region in comparison with the surrounding cities. The aim of this study is to verify whether the pandemic and the socio-economic processes triggered by it, such as the development of remote working, changed the process of divergence into a process of convergence, but whether the faster growth of residential property prices in the main city of the agglomeration, which started years ago, has not been stopped.

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For this purpose, $\alpha$-convergence and $\sigma$-convergence models were used. The study covers the period 2015-2021. The study area is the city of Szczecin and the four largest cities adjacent to the capital of the West Pomeranian Voivodeship in Poland.

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1. Introduction

In the world economy for years we can observe the phenomenon of polarization, which is manifested by the disappearance of the so-called middle class. Similar trends are also present on the real estate market. Although real estate prices are generally rising, they are rising faster in areas that are considered particularly attractive than in other locations. This leads to an increase in price differentiation. This increase in price differentiation can be referred to as price divergence. The opposite of divergence is convergence, which can be defined as the conjunction of the value of a given phenomenon to its level considered as a reference point, which is a kind of normative value. In the case of analyzing real estate markets, such a reference point may be large cities, which are the centers of larger agglomerations that gather around such large cities several smaller ones, forming one urban organism.

The outbreak of the COVID-19 pandemic has left a great mark on all of humanity. In addition to the immediate threat to health and life, the virus somehow also infected other spheres of human life. The lockdowns that lasted for many weeks had a very big impact on various sectors of the economy. Most of them experienced a severe slowdown or recession. However, there were areas that benefited from the fact that the people of particular countries stayed at home and worked remotely. Examples of such areas include the computer market, tablets, online stores, and delivery companies. This proves that even in difficult circumstances like a pandemic, we are not facing a total global recession. In such a context, it is worth looking at the impact of the COVID-19 pandemic on the real estate market. This area of the economy can experience the impact of the virus in different ways. On the one hand, a general increase in global uncertainty can cause certain investment projects to freeze or be abandoned. Lockdowns cause difficulties in accessing workers at construction sites. Populations losing their jobs during a pandemic have difficulty paying rent or mortgage payments. On the other hand, rising inflation and low interest rates on bonds and bank deposits may encourage people to protect their savings by buying property. Remote working increases the demand for larger apartments that need to serve as offices in addition to residential functions. Remote work also means not having to commute to workplaces, which may encourage people to move to cheaper locations without having to give up a well-paying job in a larger but also more expensive city. These two groups of impulses are opposite and may have completely different impact on the real estate market, understood as the level of prices and number of transactions.

The study is part of a broader research effort to assess the impact of the COVID-19 pandemic on various areas of the economy. The subject of the study is the residential real estate market in the Szczecin agglomeration - one of the largest Polish cities. The study covered the years 2015-2021. The study period was divided into the period 2015-2019, which is the time before the outbreak of the pandemic. The second period is 2020-2021, which is the duration of the pandemic (still ongoing - as of the beginning of 2022). The aim of the study is to verify the hypothesis that the COVID-19 pandemic influenced the formation of prices in the housing market through increased attractiveness, and thus greater demand and price growth in the smaller cities that are part of a larger agglomeration, compared to prices in the central city.

2. Literature review

The concept of convergence means conjunction of the analyzed phenomenon to its normative level. In convergence studies, the rate and direction of convergence are evaluated, which allows to assess whether the subjects of the study become similar as to the level of the analyzed phenomenon and after what time their similarity will occur. The phenomenon of convergence has been extensively described in scientific research around the world in various fields. [1] proposed a new panel data model representing the behavior of economies in transition, and developed econometric
methods used to analyze the convergence of cost-of-living indices in 19 American metropolitan cities. Batóg [2] signaled the problem of outlier observations in the study of convergence. The paper [3] analyzed real convergence of GDP per worker in EU member states. The study [4] concerns the club convergence of per capita transport carbon emissions in China. In contrast, [5] presented econometric convergence tests and club clustering using Stata software. [6] looked at the stochastic analysis of EU countries' convergence to the EU15 weighted average GDP. It was shown that only few countries achieve stochastic convergence, both in absolute and conditional sense. Convergence studies can also be conducted on the real estate market. The objects of analysis in such cases are usually residential properties. In [7] authors studied 10 representative key cities in China, which can be divided into clubs. It was noted that house prices in cities in the same club show a clear convergence. The Chinese real estate market in the context of convergence was also addressed in the study [8]. The study used a nonlinear time-varying factor model. It proved the existence of a certain degree of segmentation in the Chinese housing market. The study [9] looked at the convergence of house prices in southern Africa. It analyzed whether the law of one price (LOOP) holds in the housing market of five metropolitan areas in South Africa. Evidence of LOOP was found in twelve of the fifteen cases. A time-varying analysis of urban house price volatility in the four largest Eurozone countries compared to those in the United States was conducted in a paper [10]. The paper [11] examined the convergence of housing prices at the regional and state level in the United States. Convergence σ was used, in which regional and state variances are calculated to test hypotheses. Price convergence has also been studied in the UK property market [12]. It was observed that house prices in UK regions can be grouped into four groups, confirming the heterogeneity and complexity of this housing market. In turn, the paper [13] investigated the extent of convergence club formation in local house prices in England and Wales. The study used a large aggregate dataset from a study period spanning over twenty years. Divergence clubs or multiple house price convergence clubs were found rather than a single club. It was noted that convergence is less likely for single-family, semi-detached and terraced housing than for apartments. The answer to the question of whether regional house prices are converging in Turkey was sought in the article [14]. It was shown that the regions can be divided into seven convergence clubs and one divergence club, confirming the heterogeneity and complexity of the Turkish housing market. Regarding the Polish achievements in real estate market convergence research, the article [15] notes that average residential real estate prices tend to show considerable regional variation, reflecting the different social, economic or historical determinants of the development of these markets. Previous research has not provided strong evidence to support the convergence of house price levels on a regional basis. This study [16] focused on the basic determinants in the residential real estate market (primary, secondary and rental) in the 16 largest cities in Poland. It has been confirmed that the situation in the residential market depends on fundamental factors and the best way of further econometric analysis is to divide the whole market into two groups (cities with population below and above 400,000 inhabitants). In turn [17] attempted to determine whether there is a common trend in house prices in provincial capitals in Poland. It was shown that the cities do not have a common price in the long run, but nevertheless there are convergence clubs in both primary and secondary markets. Convergence of regional real estate markets was the focus of the paper [18]. It examined not only real estate prices but also household purchasing power in housing markets. An extensive study of convergence processes in European housing markets was carried out in [19]. Despite its dominance in the literature, not only residential real estate has been the subject of convergence studies. In the paper [20] the convergence of agricultural land prices in the European Union was studied. A broad review of the literature shows that the phenomenon of price convergence occurs in different markets in different ways, at different rates and in different directions (price convergence or divergence may occur). This diversity of phenomena in local real estate markets has been compounded by the COVID-19 pandemic since 2020, and its impact on various aspects of life and health cannot be overstated. The pandemic has affected every sector of the economy, including the real estate market. Researchers from around the world have been studying the impact of the pandemic on the real estate market [21-25]. The phenomenon of price convergence has also been studied in this context [26]. However,
there are not many research on how on the course of previous phenomena of convergence or divergence of real estate prices. The present research tries to fill this research gap at least partially.

3. Material and Methods

The conducted study is based on the analysis of transaction prices per square meter obtained in the market of residential units in 2015-2021. The data used in this study came from the author's own database and information obtained, among others, from real estate price registers. In the set, transactions of sales of residential real estate concerning both the ownership right and the cooperative ownership right to premises were identified. Geographically, the study covers five cities of one of the Polish provinces, the West Pomeranian Province. Figure 1 shows the location of the analyzed cities in the Western Pomeranian Voivodeship and the location of the Voivodeship itself in Poland. The analyzed dataset includes a total of 28,946 observations. Each transaction was described by three attributes: the name of the city, the date of the transaction, and the price per square meter.

The aim of this study is to determine whether and how the occurrence of the COVID-19 pandemic has affected the phenomenon of convergence/divergence of real estate prices in the Szczecin agglomeration. The point of reference here is the regional capital, Szczecin. In addition, the study included the four largest satellite cities: Goleniów, Gryfino, Police and Stargard. These cities, thanks to improving transport connections with Szczecin, are becoming, at least in the sense of economic and demographic processes, a more and more stable urban organism. This growing interdependence can also influence the real estate market. Traditionally, prices in cities close to large agglomerations are significantly lower. This prompts real estate market participants who simultaneously work in a large city to purchase property farther away from the central city, which involves the cost and time of a daily commute. If the opportunities to use the city's amenities were to increase, for example, due to improvements in the road network, the demand for properties in smaller cities would increase, which would raise their prices. Such a phenomenon could result in the emergence of price convergence. Verification of whether such a phenomenon was occurring in the study area and whether its nature was influenced by the pandemic that disrupted population movement processes will be carried out based on two convergence models: alpha convergence and sigma convergence.

![Fig. 1. Location of analyzed cities in Western Pomeranian voivodship and location of the voivodship itself in Poland.](image)

The study uses two approaches to study the convergence phenomenon. The first is $\alpha$-convergence and the second is $\sigma$-convergence.

**Nomenclature**

| Symbol          | Description                                      |
|-----------------|--------------------------------------------------|
| $\max Y_{it}$   | maximum values of average prices achieved in the group of cities in particular research periods |
| $\min Y_{it}$   | minimum values of average prices achieved in a group of cities in particular survey periods   |
| $\alpha_{1max}, \alpha_{0max}$ | coefficients of linear trend for maximum values |
\[ \alpha_{1\min}, \alpha_{0\min} \] coefficients of linear trend for minimum values

\[ u_{\max}, u_{\min} \] random component

\[ \sigma_{\ln Y_{t0}}, \sigma_{\ln Y_{t0+T}} \] standard deviation of average prices in the analyzed group of objects in periods \( t_0 \) and \( t_0 + T \)

\( T \) the length of the interval of empirical verification of the convergence phenomenon

Testing for the presence of \( \alpha \) convergence involves comparing the directional trend coefficients for the logarithms of the values of the phenomenon under analysis. Trends are estimated for the maximum and minimum values in each period \( t \). These observations for each period need not be values for the same object. These trends are called marginal trends:

\[
\ln\left(\max_i Y_{it}\right) = \alpha_{0\max} + \alpha_{1\max} t + u_{\max} \\
\ln\left(\min_i Y_{it}\right) = \alpha_{0\min} + \alpha_{1\min} t + u_{\min}
\]

When the slope coefficient estimates are statistically significant and an inequality exists:

\[
\hat{\alpha}_{1\max} < \hat{\alpha}_{1\min}
\]

then \( \alpha \)-convergence is said to occur.

The second type of convergence used in the study is \( \sigma \)-convergence. A group of objects is said to be \( \sigma \)-convergent if the dispersion of the phenomenon analyzed for them (average property prices) shows a downward trend. The simplest way to confirm the existence of \( \sigma \)-convergence is the truth of the inequality:

\[
\sigma_{\ln Y_{t0}} - \sigma_{\ln Y_{t0+T}} > 0
\]

**4. Empirical results**

The study uses data on residential transactions in five cities between 2015 and 2021. The study period is divided into two sub-periods. The first includes transactions from 2015-2019. This is the period before the outbreak of the COVID-19 pandemic. The second sub-period is 2020-2021 is the duration of the pandemic (not yet over). Figure 2 shows the development of average prices per square meter in all analyzed cities by the described sub-periods. It may be noticed that both in the city (Szczecin), which is a reference point for price convergence observations, and in the remaining cities, increasing price tendencies are observed.

![Fig. 2. Average transaction prices of residential units in the analyzed cities in the pre-pandemic period (left graph) and in the COVID-19 pandemic period (right graph).](image)

Careful analysis of these time series using formulas 1-4 will allow to assess whether or not prices in smaller towns were approaching those in the metropolitan area. The survey was conducted as follows. In both specified sub-periods it was determined whether there was \( \alpha \)-convergence and then \( \sigma \)-convergence. Figure 3 shows the development of maximum and minimum average prices in each sub-period both pre- and during the pandemic. In both sub-periods,
the marginal trends are increasing. In this case, one can speak of convergence if the directional coefficient of the trend for the minimum values has a larger value than the directional coefficient of the marginal trend for the maximum values. Visual analysis allows us to believe that the edge trend for maximum values is growing at a faster rate. Both in first and second sub-period.

![Graph showing boundary trends of average residential real estate prices during the pre-pandemic period (left graph) and during the COVID-19 pandemic period (right graph).](image)

The trend for maximum values in the period before the COVID-19 pandemic was:

\[
\ln \left( \max_i Y_{it} \right) = 8.192 + 0.0187t \quad \text{adj. } R^2 = 0.943
\]

Trend for minimum values from 2015 to 2019:

\[
\ln \left( \min_i Y_{it} \right) = 7.996 + 0.0122t \quad \text{adj. } R^2 = 0.898
\]

The slope of the trend for the maximum values was greater. This means that before the outbreak of the pandemic there was no \(\alpha\)-convergence of prices in the analyzed cities.

For pandemic duration, the analogous trend patterns were as follows:

The trend for the maximum values during the pandemic period was:

\[
\ln \left( \max_i Y_{it} \right) = 8.613 + 0.0278t \quad \text{adj. } R^2 = 0.928
\]

Trend for minimum values in 2020-2021:

\[
\ln \left( \min_i Y_{it} \right) = 8.337 + 0.0158t \quad \text{adj. } R^2 = 0.562
\]

Also in this case, the slope of the trend for the maximum values was greater. The pandemic period did not reverse the phenomenon of widening differences between prices in the analyzed cities. The phenomenon of convergence in the sense of \(\alpha\) did not occur. Moreover, the difference in the slopes of the trends increased. The phenomenon of price divergence in the Szczecin agglomeration intensified.

In research, there are many times when the choice of research tool determines the conclusions obtained. Changing the tool may lead to different conclusions. In order to eliminate the risk that the assessment of price divergence depends on the way it is measured, residential real estate price convergence was examined using a different approach, \(\sigma\)-convergence. As previously described, it is based on the comparison of price volatility at the beginning and the end of the examined period. Figure 4 presents the evolution of standard deviations of logarithms of average prices from the surveyed cities in the analyzed quarters.
Fig. 4. Standard deviations of average transaction prices in the analysed cities.

In the case of the pre-pandemic period, a clear increasing trend of variation in average prices can be observed. The standard deviation of prices in the first quarter analyzed was 0.0859, while in the last quarter it was 0.136. Such values mean that inequality (4) is not satisfied, so the phenomenon of convergence does not occur. The assessment of the occurrence of σ-convergence during the COVID-19 pandemic is ambiguous. While the trend of price variation is increasing, the value of the standard deviation of prices in the last analyzed quarter itself turned out to be slightly smaller (0.117) than the price variation measured in the first quarter of the pandemic (0.136). However, when analyzing the trend, it can be assumed with high probability that the price variation will continue to increase, which means, as in the case of the α-convergence study, that there is no price convergence in the Szczecin agglomeration’s housing markets.

5. Conclusions

The study was devoted to the verification of the hypothesis that the COVID-19 pandemic influenced the formation of prices in the housing market by increasing the attractiveness, and thus the greater demand and price growth in cities that are part of a larger agglomeration, compared to prices in the central city. This hypothesis is supported by declarations of the real estate market participants that in the era of remote work, they will not have to bear higher costs of purchasing real estate in a large city where they work. They will be able to purchase or rent housing in cities where prices are lower, but they will not have to give up their jobs in the big city. Such decisions, if translated into actual real estate transactions, should lead to price increases in smaller cities and curb price increases in larger ones.

In order to assess whether such a phenomenon actually occurred, the measurement of price convergence was used. Two approaches to convergence measurement were used: α-convergence and σ-convergence. Convergence of the alpha type is based on the marginal trends of the analyzed prices. On the other hand, the occurrence of sigma-type convergence is assessed based on the decrease in price volatility. Both approaches used showed that the assumed research hypothesis is not true. The study period was divided into two sub-periods. In the first one, which included 2015-2019, there was price divergence. This means that price differentiation was increasing. Prices in the central city of the analyzed agglomeration grew more than in the satellite cities. This character of prices was anticipated. The second sub-period of the analysis was the COVID-19 pandemic period. It covered the years 2020-2021. The alpha-type convergence measurement showed that not only was there no price similarity phenomenon, but on the contrary. Prices in Szczecin grew faster than in neighbouring cities. This conclusion was also confirmed by sigma type convergence measurements. In 2015-2019, an upward trend in price dispersion was observed, caused mainly by faster price growth in the center of the agglomeration. Residential property prices also rose in the smaller cities analyzed, but not as fast. Price differentiation also increased during the pandemic period, although in this case, due to the smaller number of observations (8 quarters), it is difficult to find a clear trend. In the last quarter, price differentiation clearly declined.
The COVID-19 pandemic is not over yet. Observations of the real estate market in the coming quarters need to continue in order to draw definitive conclusions regarding the change in preferences of property buyers. Observations so far do not confirm a decline in interest in residential units in the main city in favor of properties in surrounding cities.

The identification of processes related to the convergence of real estate prices in agglomerations may constitute an element of investment decision support systems that aim at searching for market opportunities that will allow to achieve above-average rates of return. The knowledge of whether prices in satellite towns of large urban centers grow faster or slower than prices in the central city may be an important input into the decision support system for creating investment portfolios on the real estate market.

Future research in this area should focus on further analysis of the impact of the pandemic on real estate markets. Moreover, the impact of the pandemic on price formation will also be indirect. For some time now, a global increase in inflation has been observed, which gives an additional impulse to the purchase of real estate financed by savings, which are losing their value in the form of bank deposits. On the other hand, the increase in inflation entails an increase in interest rates. In countries such as Poland, where variable-rate mortgages predominate, the rise in interest rates is a factor that limits the number of loans granted. Thus, on the one hand there is an impulse to purchase real estate financed by savings, while on the other hand there is a decrease in lending activity in the mortgage lending sector. It will be very interesting to observe which of these opposing factors will have the prevailing influence on the real estate market in the near future. This future is additionally uncertain due to the war in Ukraine, whose human sacrifice dimension is enormous, but which will also affect various sectors of the global economy, including the real estate market.

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References

[1] P.C.B. Phillips, D. Sul, TRANSITION MODELING AND ECONOMETRIC CONVERGENCE TESTS, 2007. http://www.econometricsociety.org.
[2] J. Batóg, Identification and significance of atypical observations in income convergence models, Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie. (2015) 5-15. https://doi.org/10.15678/znuek.2015.0941.0501.
[3] Cuestas, JC, Monfort, Ordóñez, Real convergence in Europe: a cluster analysis, 2012. https://eprints.whiterose.ac.uk/.
[4] C. Bai, Y. Mao, Y. Gong, C. Feng, Club convergence and factors of per capita transportation carbon emissions in China, Sustainability (Switzerland). 11 (2019). https://doi.org/10.3390/su11020539.
[5] K. Du, Econometric convergence test and club clustering using Stata, 2017.
[6] B. Witkowski, M. Próchniak, Stochastic Convergence of the European Union Countries: A Conditional Approach 1, n.d.
[7] H. Meng, W.-J. Xie, W.-X. Zhou, Club Convergence of House Prices: Evidence from China's Ten Key Cities, (2015). https://doi.org/10.1142/S0217979215501817.
[8] R. Lin, X. Zhang, X. Li, J. Dong, Heterogeneous convergence of regional house prices and the complexity in China, Zbornik Radova Ekonomskog Fakultet Au Rijeci. 33 (2015) 325-348. https://doi.org/10.18045/ZBEFRI.2015.2.325.
[9] S. Das, R. Gupta, P.A. Kaya, CONVERGENCE OF METROPOLITAN HOUSE PRICES IN SOUTH AFRICA: A RE-EXAMINATION USING EFFICIENT UNIT ROOT TESTS, 2010.
[10] P. Hiebert, M. Roma, Working Paper Series No 1206 / June 2010 relative housE Price dynamicS acroSS euro area and uS citieS convergence or divergence?, 2010. http://www.eeb.europa.eu.
[11] E. Nissan, J.E. Payne, A Simple Test of σ-Convergence in U.S. Housing Prices across BEA Regions, 2013.
[12] A. Montagnoli, J. Nagayasu, UK house price convergence clubs and spillovers, Journal of Housing Economics. 30 (2015) 50-58. https://doi.org/10.1016/j.jhee.2015.10.003.
[13] M.J. Holmes, J. Otero, T. Panagiotidis, PROPERTY HETEROGENEITY AND CONVERGENCE CLUB FORMATION AMONG LOCAL HOUSE PRICES Property Heterogeneity and Convergence Club Formation among Local House Prices *, 2018. www.rcea.org.
[14] A. Ganioglu, Ü. Seven, Do regional house prices converge? Evidence from a major developing economy, Central Bank Review. 21 (2021) 17-24. https://doi.org/10.1016/J.CBREV.2021.03.001.
K. Żelazowski, Price Convergence in the Regional Housing Markets in Poland, Real Estate Management and Valuation. 27 (2019) 44-52. https://doi.org/10.2478/remav-2019-0014.

G. Baldowska, R. Leszczyński, B. Myszkowska, Convergence and differentiation processes in local markets and structural changes (comparison of 16 markets in Poland), 2014. www.nbp.pl.

M. Tomal, House Price Convergence on the Primary and Secondary Markets: Evidence from Polish Provincial Capitals, Real Estate Management and Valuation. 27 (2019) 62-73. https://doi.org/10.2478/remav-2019-0036.

K. Żelazowski, Convergence in regional housing markets in Poland, Ekonomia XXI Wieku. 3 (2018) 53-64. https://doi.org/10.15611/e21.2018.3.04.

E. Kucharska-Stasiak, E. Kusidel, M. Załęczna, K. Żelazowski, Convergence processes on European housing markets. Ujęcie międzynarodowe i regionalne, Wydawnictwo Uniwersytetu Łódzkiego, 2020. https://doi.org/10.18778/8142-936-8.

A. Twardowska, Convergence of sigma type of agricultural land prices in the European Union countries, Zeszyty Naukowe SGGW w Warszawie - Problemy Rolnictwa Światowego. 19 (2019) 133-143. https://doi.org/10.22630/prs.2019.19.1.12.

N. Balemi, R. Füss, A. Weigand, COVID-19's impact on real estate markets: review and outlook, Financial Markets and Portfolio Management. 35 (2021) 495-513. https://doi.org/10.1007/s11408-021-00384-6.

M. Bełej, Housing price forecasting in selected Polish cities during the covid-19 pandemic, Geomatics and Environmental Engineering. 15 (2021). https://doi.org/10.7494/geom.2021.15.4.59.

M. Koszel, The COVID-19 Pandemic and the Professional Situation on the Real Estate Market in Poland, in: Proceedings of the International Scientific Conference Hradec Economic Days 2021, University of Hradec Kralove, 2021: pp. 412-425. https://doi.org/10.36689/uhk/hed/2021-01-042.

N. Ho Phi, Factors Affecting Real Estate Prices During the COVID-19 Pandemic: An Empirical Study in Vietnam, Journal of Asian Finance. 8 (2021) 159-0164. https://doi.org/10.13106/jafeb.2021.vol8.no10.0159.

P. de Toro, F. Nocca, F. Buglione, Real Estate Market Responses to the COVID-19 Crisis: Which Prospects for the Metropolitan Area of Naples (Italy)?, Urban Science. 5 (2021) 23. https://doi.org/10.3390/urbansci5010023.

M. McCord, D. Lo, J. McCord, P. Davis, M. Haran, P. Turley, The impact of COVID-19 on house prices in Northern Ireland: price persistence, yet divergent?, Journal of Property Research. (2022). https://doi.org/10.1080/09599916.2021.2023610.