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AN ANALYSIS OF THE RELATIONSHIPS BETWEEN DOMESTIC REAL ESTATE MARKETS – A SYSTEMIC APPROACH

Justyna Brzezicka, PhD
Faculty of Geodesy, Geospatial and Civil Engineering
University of Warmia and Mazury in Olsztyn
e-mail: justyna.brzezicka@uwm.edu.pl

Jacek Łaszek, Assoc. Prof., PhD
Collegium of Business Administration
Warsaw School of Economics, Narodowy Bank Polski
e-mail: jacek.laszek@nbp.pl

Krzysztof Olszewski, PhD
Collegium of Business Administration
Warsaw School of Economics, Narodowy Bank Polski
e-mail: krzysztof.olszewski@nbp.pl

Abstract

This article analyzes the spread of market phenomena, market tensions and trends between real estate markets on the global scale. At the theoretical level, the main aim of the study was to determine the nature of the relationships between housing markets throughout the world. The main research goal was to identify and describe the strength of the correlations between the real estate markets of the world's 10 largest economies (countries with the highest GDP). The analyses were conducted with the use of Pearson's correlation tests, Granger causality tests and graphs. Our results revealed strong correlations between most of the markets; however, we did not find strong evidence for causality. In a globalizing world, national economies will become increasingly interconnected, which will indirectly influence the housing market.

Keywords: *International house prices, spillovers, financial globalization*.

JEL Classification: *R10, R30.*

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1. Introduction

In developed countries, the real estate market, in particular the housing market, plays a key role in economic and social development (ŁASZEK 2004). The performance of the real estate market is a reflection on a country's macroeconomic development and economic growth. However, the real estate market is also a sub-sector of the economy which drives economic growth by directly interacting with the construction industry and the financial sector. In many countries, the wealth effect generated by the increase in house prices, which can even lead to equity withdrawal, has a strong effect on consumption. Mortgage financing on the residential market has led to many crises and recessions.

This article analyzes the spread of market phenomena, market tensions and trends between national real estate markets. At the theoretical level, the main aim of the study was to determine the nature of the relationships between housing markets throughout the world. The main research goal was to identify and describe the strength of the correlations between the real estate markets of the world's 10 largest economies (countries with the highest GDP in terms of current prices in USD). The analyses were conducted with the use of Pearson's correlation tests, Granger causality tests and diagrams. The findings were critically discussed.

2. Literature review

In the literature, the housing market has been long regarded as a local market (BECK, SCOTT, YELOWITZ 2012; KUCHARSKA-STASIAK et al. 2009; LING 1992) due to scarce international trade, absence of cross-border financing options and the immobile nature of the residential sector (GALATY, ALLAWAY, KYLE 2003, p. 4; GELTNER et al. 2013, p. 4; HAILA 2000; LUCIUS 2001, p. 75; LUSHT 1988). In a globalizing world, national economies are becoming increasingly interconnected, and the global financial system also plays a major role in shaping local housing markets. The convergence of regulatory approaches to real estate in different countries also contributes to the convergence of housing markets. International links are established indirectly by relying on international mortgages, transfer of ownership rights and the effects of institutional investments. Buyers, developers and financing banks are increasingly mobile, which contributes to the translocal character of the housing market (SÖDERSTRÖM, GEERTMAN 2013; MAIN, SANDOVAL 2015; BRZEZICKA, WISNIEWSKI 2015, 2016; PORST, SAKDAPOLRAK 2017).

The real estate market is strongly connected with the financial system, which is undergoing rapid globalization. Until the 1990s, each country had its own housing finance system which was separate from the global financial system. Banks are reluctant to finance transnational house purchases due to different housing policies, eviction rules and legal regulations. At present, most housing purchases are financed by universal banks that operate internationally and are, in many ways, connected to banks in other countries. The globalization of the financial markets is largely responsible for the synchronization of real business cycles, which, in turn, should lead to the synchronization of real estate cycles. Empirical data (ANDRÉ 2010; ANDREWS et al. 2011) as well as theoretical models indicate that synchronization can be stimulated or hampered by additional factors such as legal regulations. Local business cycles are also an important factor, especially if they have recently ended in a crisis. If this is the case, even the most supportive conditions on the international market will have little effect on the local housing market.

Mortgages usually play a significant role in residential property purchases, and interest rates have a strong and direct effect on house prices (BURNHAM 1972). A mortgage splits the value of the purchased property (which is unaffordable for many buyers) into many small monthly payments which are directly determined by the mortgage rate, namely the interbank interest rate plus the bank's lending margin. The lending margin covers the lending risk and generates a profit. When wealthy countries have an abundance of capital, this capital flows to countries that are in need of capital and have a relatively high interbank rate. The interbank rate will initially decrease, but increased competition between banks will increase the interbank rate and, consequently, the lending margin. As a result, the cost of a mortgage in countries which have less capital begins to decrease significantly, and the financing conditions in both groups of countries begin to converge.

Globalization has intensified the flow of capital in the form of bank credits, foreign direct investments and foreign portfolio investments. While bank credit has a very timely effect, other flows have a medium run effect, which, however, can accelerate in some situations. In the case of foreign direct investments (FDI), firms seek new markets and invest abroad, either by buying existing firms, or by creating new ones. The literature concludes that, on average, FDI improves the total factor productivity in the host country, adds to the creation of the capital stock and increases wages. Rising wages allow more households to satisfy their housing needs and buy property. It should be noted that the share of FDI that goes directly into the real estate sector varies significantly among OECD countries (HUMANICKI, OLSZEWSKI 2018), and considerable funding goes to commercial real estate. To a certain extent, foreign portfolio investments cover investments in government bonds, which decreases their profitability. Local investors begin to search for alternatives with a higher rate of return, and analyze the housing market. The inflow of bank credit also decreases mortgage costs, and investments in housing for rent become more profitable and increase the demand for housing. Large foreign portfolio investments can generate demand shocks in a relatively short time.

In the discussed approach, the economic system, in particular financial, banking and tax systems (WIŚNIEWSKI 2007, p. 18), influence the real estate market through interest rates (ŁASZEK, AUGUSTYNIAK, WIDŁAK 2009, p. 3), lending channels for private and institutional investors (IACOVIELLO, MINETTI 2008), discount rates (ŁASZEK, AUGUSTYNIAK, WIDŁAK 2010, p. 6), exchange rates, the availability of investment funds, economic growth and stability, inflation rates (TAIPALUS 2006, p. 7; HARDING, ROSENTHAL, SIRMANS 2007), household savings and incomes. The above processes are integrated by a circular flow in the economy and the real estate market (cf. CASE 1992; DAVIS, HEATHCOTE 2005; IACOVIELLO 2005); however, they are effective only in the medium and long run. In the short run, which is the object of this analysis, only the demand side reacts quickly to changes in mortgage availability and, to some extent, to income growth. Real estate is a consumer as well as an investment good; therefore, the effects of price changes can differ from those described in microeconomics textbooks. When housing is a pure consumer good, households will buy more when property is cheap, or relatively cheap in relation to their incomes.

In this context, the financial and business cycles are chiefly responsible for the transfer of economic phenomena, including economic crises (FISZEDER, RAZIK, 2004; NOSEK, PIETRZAK, p. 84, 2009; WOJTYNA, p. 25, 2010; WOJTYNA, p. 14, 2011; NAZARCZUK, p. 80, 2013). The spread of market tensions and speculative bubbles should also be discussed, in particular in periods close to financial crises. The presented discussion focuses on various transmission channels, including contagious price bubbles that spread across markets. Contagious bubbles have been identified on the stock market (SAKOLSKI 1932 based on CAIRNS 2014, p. 1) and the information technology market as dot-com bubbles (DHOLAKIA, TURCAN 2013, 2014). They are associated with an epidemic-like spread of crises (BAIG, GOLDFAJN 1999; KIM, KOO 1999), information (GLADWELL 2005) and tensions on the real estate market (SHILLER 2008, 2013). Contagious bubbles grow rapidly, they spread to other countries and transmit the tension to other markets (BRZEZICKA, KOBYLIŃSKA 2019). Such phenomena are at least partially responsible for the links and systemic connections between markets, and they play an important role in intermarket connections on a global scale. It should be noted that financial crises that engulf many countries in a region can synchronize housing markets, as demonstrated by the examples in Asian countries (BOND et al. 2006) and European countries (HUI, CHAN 2013). Only several years before the period analyzed in this article, the global financial crisis had spread to nearly all economies in the European Union (LO DUCA et al. 2017). LEE and LEE (2018) analyzed the volatility of house prices in the G7 countries and found very strong correlations between countries during the global financial crisis. The correlations between house prices on the international market were studied by GUPTA et al. (2014) who analyzed housing prices in 8 European countries between 1971 and 2012. Based on quarterly data, the authors observed a co-movement of house prices in Belgium, Germany and France with the aggregate price index and identified pairs of countries where house prices were correlated.

The housing market has a long history, and it has been shaped by different cultures, habits and housing policies. Market changes are long-term processes. Price fluctuations are influenced not only by current events, but they often occur in response to problems or tensions that have accumulated in previous years. The global financial crisis also had a dramatic impact on housing markets, and our analysis began shortly after the first wave of the global crisis had ended.

3. Data and methods

The quarterly real house price index was used to determine the increase in the prices of residential property in the world's 10 largest economies, i.e. countries with the highest GDP in terms of current prices in USD in 2017. Data were obtained from the International Monetary Fund (IMF 1 DATA). The analyzed countries were arranged in the following order, from the highest to the lowest GDP: (1) United States, (2) China, (3) Japan, (4) Germany, (5) United Kingdom, (6) India, (7) France, (8) Brazil, (9) Italy, and (10) Canada. Information about the real house price index was obtained from the Organization for Economic Co-operation and Development (OECD 1 DATA). The analyzed data covered 3Q2010 to 3Q2017, i.e. a total of 29 quarterly periods. The adopted number of quarterly periods represents the longest time series for which comprehensive information about index values was available for each country. The benchmark value for calculating the house price index in the evaluated period was 3Q2010 = 100. Our findings support two immediate observations: the data are non-stationary (see Fig. 1), and there is a group of countries where house prices followed a similar pattern. Germany, Japan, China, the UK and the US followed a relatively similar growth path.

Housing prices increased sharply in India. In Brazil, the initial spike in housing prices was followed by a steep decline. France had relatively stable prices, whereas a falling trend was noted in Italy. Since stational time series are needed for the Granger causality test, the test was run on the quarterly growth rates of the real house price index (see Fig. 2). The methodology is described below.

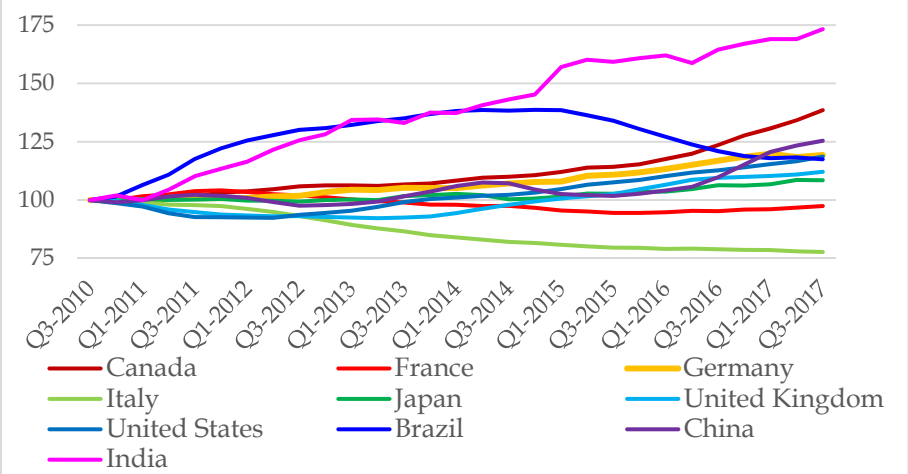

Fig. 1. Real house price indexes. *Source:* own elaboration based on OECD data.

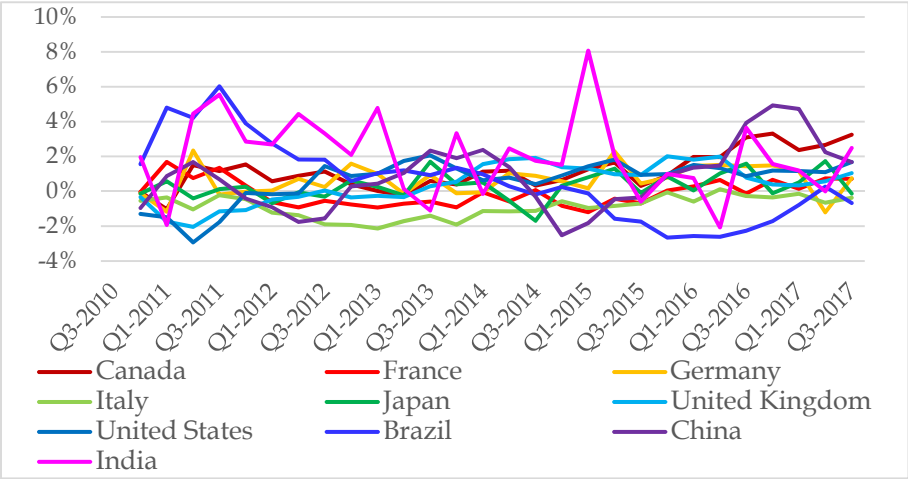

Fig.2. Quarterly increase in real house price indexes. *Source:* own elaboration based on OECD data.

The research process was divided into several stages. In the first stage, the quarterly increase in housing prices (quarterly increase in real house price indexes) was calculated with the use of Formula (1):

$$P_i = \frac{y_i - y_{i-1}}{y_{i-1}} \quad (1)$$

Pearson's correlation tests (Formula (2)) and Granger causality tests (Formulas (3), (4) and (5)) were performed. The Granger causality test is run to determine whether the lagged values of x are more useful in explaining variable y than its lagged values alone. The combined significance of those lags is tested (Formula (3)). The following hypotheses were tested: H0 – absence of Granger causality, lagged values of x are not statistically significant (Formula (4)); H1 – Granger causality, selected variables are statistically significant (Formula (5)). The above hypotheses were analyzed in the F-test to determine whether the variance of the first population was equal to the variance of the second and the next population. The test was interpreted as follows based on probability distribution: at $p < 0.05$, hypothesis H0 postulating the absence of causality should be rejected, and the alternative hypothesis H1 postulating the presence of Granger causality should be adopted. The test results were interpreted based on the p-value, because such interpretations are consistent for every pair of variables, unlike the F statistic, which is determined by the degrees of freedom, the number of observations for time series and has different critical values. P-values were calculated in EViews 7 for 1-8 lags. Lags in Granger

causality tests should be interpreted as follows: lag 1 - concerns only 1 lag; lag 2 - for lags 1-2; ..., lag 6 - applies to 1-6 lag.

$$p_{XY} = \frac{C(X,Y)}{\sqrt{{S_X}^2 {S_Y}^2}} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \sum_{i=1}^{n}(y_i-\bar{y})^2}} = \frac{C(X,Y)}{S_X S_Y} \quad (2)$$

$$y_t = A_0 D_0 + \sum_{i=1}^{n} \alpha_i y_i + \sum_{i=1}^{n} \alpha_i x_{t-i} + \varepsilon_i \quad (3)$$

$$\beta_1 = \beta_2 = \cdots = \beta_n = 0 \quad (4)$$

$$\beta_1 \neq 0 \vee \beta_2 \neq 0 \vee \ldots \vee \beta_n \neq 0 \quad (5)$$

where: C(X,Y) – covariance between parameters X and Y; ${S_X}^2$ – variance of parameter X, ${S_Y}^2$ – variance of parameter Y; S_X – standard deviation of parameter X, S_Y - standard deviation of parameter Y; $A_0 D_0$ – deterministic part of the equation.

In the next step, the results were used to build information matrices and graphs (G) according to Formulas (6), (7) and (8). The variable pairs described by Formula (9) were not taken into account because every country was compared with another country in all cases. The second step was performed individually for all lags.

$$G = [A, R, \varphi] \quad (6)$$

$$A = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}\} \quad (7)$$

$$R = \{[a_1, a_2], [a_2, a_1], [a_1, a_3], [a_3, a_2], \ldots, [a_9, a_{10}], [a_{10}, a_9]\} \quad (8)$$

$$R' = \{[a_1, a_1], [a_2, a_2], \ldots, [a_{10}, a_{10}]\} \quad (9)$$

where: A – countable set of elements a_i (nodes), R – countable set of elements r_{ijl} (graph arches) that express relationships R described by the Cartesian product $A \times A$; R′ – countable set of elements of the Cartesian product which were omitted in the study; i – number of objects, j – number of parameters; l – number of lags; i, j = {1, 2, …, 8, 9}; $l = \{1, 2, 3, \ldots 7, 8\}$; φ – transformation produced by Formulas (10) and (11):

$$\varphi: A \times A \longrightarrow C \quad (10)$$

$$C = \begin{cases} 1 \; dla \; p < 0 \\ 0 \; dla \; p \geq 0 \end{cases} \quad (11)$$

In the last step, the results for every lag were summed up with the use of Formulas (12), (13), (14) and (15):

$$Sum\_1_{ij} = \sum_{i=1}^{9} C_{ij} \quad (12)$$

$$Sum\_2_{ij} = \sum_{j=1}^{9} Sum\_1_{ij} \quad (13)$$

$$Sum\_3_{ij} = \sum_{i=1}^{9} Sum\_1_{ij} \quad (14)$$

$$Sum\_4_{ij} = \sum_{l=1}^{8} C_{ij} \quad (15)$$

where: Sum_1_{ij} – weighted causal inference for one lag for one country; Sum_2_{ij} – weighted causal inference for all countries; Sum_3_{ij} – weighted causal inference for all lags; Sum_4_{ij} – weighted causal inference for one country for all lags.

5. Results

The correlations between markets were analyzed based on the price index and price growth rates to identify potential causalities. According to the literature, stationary time series should be analyzed, but the housing sector is generally characterized by prolonged price rises and prolonged price drops (ANDRÉ, 2010). In line with the presented theoretical considerations, house prices can move in sync or in opposite directions. At the level of the price index, our observations are similar to those presented by GUPTA et al. (2014). Countries from the previously mentioned group (Germany, Japan, China, the UK and the US) were characterized by very similar price trends. The analyzed correlations were positive in most countries; whereas the prices in Italy and France were negatively correlated with the remaining countries. Italy and France were the only two countries where house prices decreased,

which can be attributed to a housing bubble that had occurred before the global financial crisis on those markets.

The results of Pearson's correlation test are presented in Table 1 (index values) and Table 2 (increase in index values). The coefficients marked in bold and with asterisks are significant at $p < 0.05$. A correlation analysis provides information about the strength and the direction of a relationship, but it does not reveal the causality, which is determined by the Granger causality test. The analysis of price growth rates produced weaker correlations. Interestingly, growth rates in Brazil were correlated with nearly all other countries. Our results indicate that price growth in different countries can be bound by one-to-one relationships, but this process generally takes some time until the shocks from one market spread to another market. The results were processed into information matrices with Formulas (6), (7), (8), (9), (10) and (11) which are presented in Appendix 1. The values of Sum_1_{ij} calculated with Formula (12) are also presented in the tables. Table 3 presents the calculated values of Sum_2_{ij} and Sum_3_{3j} (formulas (13) and (14)), and Table 4 – the values of Sum_4_{ij} (Formula (15)). The results presented in Table 4 are the sum of the significant results obtained for each Granger causality test for up to 8 lags. We should bear in mind that the test with 3 lags also contains 2 lags and 1 lag. However, in some cases, the test becomes significant for a larger number lag than 1 and, after some lags, it becomes insignificant again. The results were used to determine the intensity of the analyzed phenomenon in graphical form in Figure 5. The results in Table 3 were used to develop a relationship graph in Figure 3. Weighted causal inference for one country for all lags (Sum_4_{ij}) was labeled with differently colored arrows, and the direction of the relationships is indicated by the direction of the arrow. Only moderate and strong relationships with weighted causal inference of 3 to 8 lags were used in further analysis (see Fig. 3). They were arranged based on the direction of the relationship, and the cycle of market trends was presented (Fig. 4).

Table 1

Pearson's correlation coefficients – house price indexes

	Canada	France	Germany	Italy	Japan	UK	USA	Brazil	China	India
Canada	1.000									
France	**-0.667***	1.000								
Germany	**0.970***	**-0.789***	1.000							
Italy	**-0.819***	**0.902***	**-0.889***	1.000						
Japan	**0.955***	**-0.655***	**0.936***	**-0.757***	1.000					
U. Kingdom	**0.865***	**-0.700***	**0.883***	**-0.660***	**0.882***	1.000				
U. States	**0.925***	**-0.842***	**0.954***	**-0.843***	**0.933***	**0.942***	1.000			
Brazil	0.034	-0.315	0.098	**-0.497***	-0.092	-0.299	-0.040	1.000		
China	**0.899***	**-0.447***	**0.817***	**-0.620***	**0.900***	**0.771***	**0.813***	-0.135	1.000	
India	**0.892***	**-0.854***	**0.939***	**-0.975***	**0.816***	**0.727***	**0.869***	**0.406***	**0.671***	1.000

Source: own elaboration.

Table 2

Pearson's correlation coefficients – increase in house price indexes

	Canada	France	Germany	Italy	Japan	UK	USA	Brazil	China	India
Canada	1.000									
France	0.293	1.000								
Germany	0.371	-0.150	1.000							
Italy	**0.476***	**0.655***	0.022	1.000						
Japan	0.264	0.035	-0.015	0.229	1.000					
UK	0.292	-0.274	0.222	0.192	0.092	1.000				
USA	0.271	**-0.481***	0.151	-0.173	0.323	**0.673***	1.000			
Brazil	**-0.445***	0.253	**-0.463***	-0.245	-0.254	**-0.819***	**-0.720***	1.000		
China	**0.542***	**0.413***	0.205	0.286	0.292	0.060	0.146	-0.270	1.000	
India	0.113	-0.301	0.121	-0.262	-0.202	-0.213	-0.218	0.279	-0.301	1.000

Source: own elaboration.

Table 3

Summation of Sum_2_{ij} and Sum_3_{ij}

x	LAG 1	LAG 1-2	LAG 1-3	LAG 1-4	LAG 1-5	LAG 1-6	LAG 1-7	LAG1- 8	x
	SUM 1	SUM 1	SUM 1	SUM 1	SUM 1	SUM 1	SUM 1	SUM 1	SUM 3
BRAZIL	1	5	1	1	2	1	1	2	14
CANADA	0	0	0	0	1	1	2	1	5
CHINA	0	2	1	1	0	1	0	1	6
FRANCE	0	0	0	0	1	0	1	0	2
GERMANY	1	3	2	3	4	2	4	3	22
INDIA	1	2	2	1	0	0	0	0	6
ITALY	1	1	0	1	1	0	1	0	5
JAPAN	1	3	2	3	2	1	1	0	13
UK	1	2	0	0	2	0	1	0	6
USA	1	2	2	1	1	0	0	0	7
SUM 2	7	20	10	11	14	6	11	7	X

Source: own elaboration.

Table 4

Summation of Sum_4_{ij}

SUM	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA
BRAZIL	X	3	3	1	2	2	2	1	0	0
CANADA	0	X	1	0	0	0	0	0	0	4
CHINA	2	1	X	0	2	0	0	0	0	1
FRANCE	0	0	0	X	0	0	1	1	0	0
GERMANY	8	1	6	0	X	0	2	3	0	2
INDIA	0	2	0	3	0	X	0	0	0	1
ITALY	0	2	0	2	0	0	X	0	0	1
JAPAN	0	0	2	4	0	4	3	X	0	0
UK	2	0	0	2	1	0	1	0	X	0
USA	2	0	0	2	0	1	2	0	0	X

Source: own elaboration.

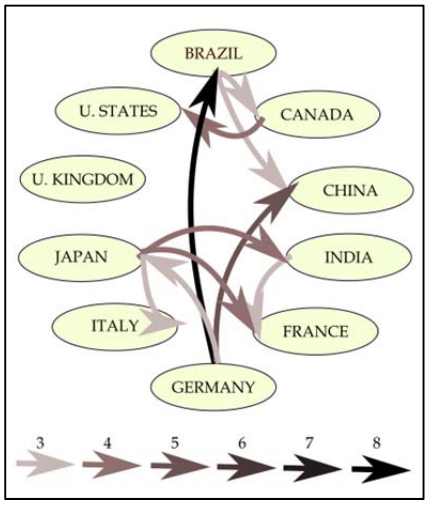

Figure 3. Relationship graph for all lags. *Source:* own elaboration.

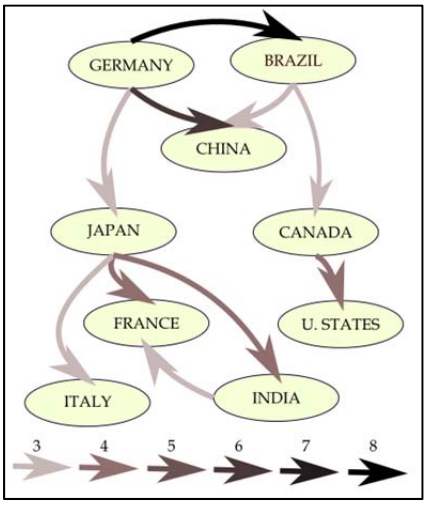

Figure 4. Cycle of market trends. *Source:* own elaboration.

SUM 1	SUM 2	SUM 3	SUM 4
0	0	0	0
1	1-10	1-8	1
2	11-20	9-16	2
3	21-30	17-24	3
4	31-40	25-32	4
5	41-50	33-40	5
6	51-60	41-48	6
7	61-70	49-56	7
8	71-80	57-64	8
9	81-90	65-72	-

Figure 5. Intensity of the studied phenomenon. *Source*: own elaboration.

Only correlations were determined between the analyzed markets. We did not find many causal relationships, and many relationships were difficult to explain. The values of Sum_1_{ij} indicate that weighted causal inference differed across countries for various lags and was not clearly ordered in time. The addition of Sum_1_{ij} and Sum_2_{ij} revealed that cumulative weighted causal inference for all countries decreased with an increase in lag. Despite the above, the analyzed relationship was characterized by a decrease in discrete values, and the linear trend could not be fitted to function Sum_2_{ij} for parameters $l = \{1, 2, 3, \ldots 7, 8\}$. The values of Sum_3_{ij} indicate that weighted causal

inference was highest in Germany ($Sum\_3_{ij} = 22$), Brazil ($Sum\_3_{ij} = 14$) and Japan ($Sum\_3_{ij} = 13$). Sum_4_{ij} provides additional information about individual relationships for every lag. Germany had a strong influence on other housing markets due to high immigration levels and because it is considered a safe haven for capital (VOIGTLÄNDER, 2017). However, we would expect the increase in housing prices to spread to neighboring, but not distant countries. Germany's influence on Brazil and Japan's influence on France are very difficult to explain. Network connections with feedback between variables are presented in Table 4. These connections were complex; therefore, only moderate and strong correlations which reduced WtoW connections to strong 1to1 (one to one) or 1to2 or 1to3 connections were retained. The two strongest correlations (Table 4, Fig. 3, Fig. 4) were 1to1 connections – "Germany causes Brazil" and "Germany causes China". The strength of these correlations was determined at 8 and 6, respectively (on a scale of 1-9, where 9 is strongest, and 1 is weakest). Ten relationships had a strength of 3 to 8 (Fig. 3 and Fig. 4). It is worth noting that the United Kingdom was not correlated with any other country (it is not the cause or the effect of the influence exerted by other countries). The cycle of market trends presented in Figure 4 is only a fragment of the analyzed market reality. It presents causal factors at different levels, which means that these factors occurred simultaneously in time. Therefore, Germany did not initiate the cause-and-effect cycle, and it was only the start point in a flowchart illustrating, in a simplified manner, the multi-dimensional space of elementary events which were identified with the use of the described methods.

5. Research limitations

The authors are fully aware that the study is not free of limitations. The main limitation stems from the assumption that global markets belong to a single economic space and are bound by indirect, rather than direct relationships. The evaluated countries are bound by nodes and relationships in the network of economic interconnections, and the real estate market is only a small fragment of economic space which is influenced by these processes. The analyzed relationships stem from the fact that countries are subject to the same processes. The direct analysis did not reveal any relationships because an international housing market does not exist. Property markets are local, and market changes are influenced by endogenous factors. Meanwhile, this study investigated exogenous factors by relying on other countries to explain the situation in the analyzed country. The processes observed on the housing market are often very complex and historically determined. The domestic housing market is unlikely to be affected when a positive global demand shock follows a steep decrease in local prices. The above considerations apply especially in an object-oriented approach (focusing on real estate), whereas our study relies on a subject-oriented, translocal and systemic approach, which leads to the transfer of systemic elements. The second limitation was that a different criterion for selecting the world's 10 largest economies would produce different results. For example, the GDP per capita or disposable income could better illustrate the allocation of resources on the real estate market. The analysis also relied on aggregate data, which implies that house price indexes in different countries can account for different types of residential property. Moreover, the differences between local markets in a single country can be enormous, as demonstrated by MALPEZZI (2015, Figures 12 and 13) for 143 metropolitan areas in the USA, and they are impossible to capture with a single price index.

6. Discussion and Conclusions

The analysis of house prices in the world's 10 largest economies revealed a strong correlation between those markets, but we were unable to find evidence for causal relationships. The demand for housing is determined by economic growth, and the synchronization of national economies in a globalizing world also applies to housing markets. Interestingly, housing prices in Italy and France were negatively correlated, which could be attributed to the fact that they were the only two countries where real house prices decreased over the analyzed period. This decrease resulted from a housing bubble which occurred in Italy and France around the period of the global financial crisis, and which continues to exert a negative impact on those markets. The analysis of house price growth based on the Granger causality method revealed that the German housing market, followed by Brazil and Japan, exerted the greatest impact on other economies. Where the influence wielded by Germany, the main driving force behind the growth of the EU market, is rather natural, the impact of Brazil or Japan on other markets cannot be reasonably explained. This leads us to conclude that causal relationships

cannot be directly observed due to the complexity of local housing markets and the occurrence of global and local housing cycles. Further research should focus on a region, which is not only economically but also geographically related. Such a region is the European Union, where the prices of the capital cities should be studied. In such a way the problem of the aggregation of local, national housing markets is solved and relationships between quite close markets can be analyzed.

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Appendix 1

Table 1A

Information matrix for only 1 lag

LAG 1	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	U. K.	U. S.	SUM 1
BRAZIL	X	0	0	0	0	1	0	0	0	0	1
CANADA	0	X	0	0	0	0	0	0	0	0	0
CHINA	0	0	X	0	0	0	0	0	0	0	0
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	0	0	X	0	0	0	0	0	1
INDIA	0	0	0	0	0	X	0	0	0	1	1
ITALY	0	1	0	0	0	0	X	0	0	0	1
JAPAN	0	0	1	0	0	0	0	X	0	0	1
U. KINGDOM	1	0	0	0	0	0	0	0	X	0	1
U. STATES	1	0	0	0	0	0	0	0	0	X	1

Source: own elaboration.

Table 2A

Information matrix from 1 to 2 lags

LAG 2	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	1	1	1	1	1	0	0	0	0	5
CANADA	0	X	0	0	0	0	0	0	0	0	0
CHINA	1	0	X	0	1	0	0	0	0	0	2
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	1	0	X	0	0	1	0	0	3
INDIA	0	1	0	1	0	X	0	0	0	0	2
ITALY	0	1	0	0	0	0	X	0	0	0	1
JAPAN	0	0	0	1	0	1	1	X	0	0	3
UK	1	0	0	0	1	0	0	0	X	0	2
USA	1	0	0	0	0	1	0	0	0	X	2

Source: own elaboration.

Table 3A

Information matrix from 1 to 3 lags

LAG 3	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	0	1	0	0	0	0	0	0	0	1
CANADA	0	X	0	0	0	0	0	0	0	0	0
CHINA	0	0	X	0	1	0	0	0	0	0	1
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	1	0	X	0	0	0	0	0	2
INDIA	0	1	0	1	0	X	0	0	0	0	2
ITALY	0	0	0	0	0	0	X	0	0	0	0
JAPAN	0	0	0	0	0	1	1	X	0	0	2
UK	0	0	0	0	0	0	0	0	X	0	0
USA	0	0	0	1	0	0	1	0	0	X	2

Source: own elaboration.

Table 4A

Information matrix from 1 to 4 lags

LAG 4	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	0	0	0	0	0	0	1	0	0	1
CANADA	0	X	0	0	0	0	0	0	0	0	0
CHINA	1	0	X	0	0	0	0	0	0	0	1
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	0	0	X	0	1	1	0	0	3
INDIA	0	0	0	1	0	X	0	0	0	0	1
ITALY	0	0	0	1	0	0	X	0	0	0	1
JAPAN	0	0	0	1	0	1	1	X	0	0	3
UK	0	0	0	0	0	0	0	0	X	0	0
USA	0	0	0	0	0	0	1	0	0	X	1

Source: own elaboration.

Table 5A

Information matrix from 1 to 5 lags

LAG 5	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	0	0	0	1	0	1	0	0	0	2
CANADA	0	X	0	0	0	0	0	0	0	1	1
CHINA	0	0	X	0	0	0	0	0	0	0	0
FRANCE	0	0	0	X	0	0	1	0	0	0	1
GERMANY	1	0	1	0	X	0	1	1	0	0	4
INDIA	0	0	0	0	0	X	0	0	0	0	0
ITALY	0	0	0	1	0	0	X	0	0	0	1
JAPAN	0	0	0	1	0	1	0	X	0	0	2
UK	0	0	0	1	0	0	1	0	X	0	2
USA	0	0	0	1	0	0	0	0	0	X	1

Source: own elaboration.

Table 6A

Information matrix from 1 to 6 lags

LAG 6	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	0	0	0	0	0	1	0	0	0	1
CANADA	0	X	0	0	0	0	0	0	0	1	1
CHINA	0	1	X	0	0	0	0	0	0	0	1
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	1	0	X	0	0	0	0	0	2
INDIA	0	0	0	0	0	X	0	0	0	0	0
ITALY	0	0	0	0	0	0	X	0	0	0	0
JAPAN	0	0	0	1	0	0	0	X	0	0	1
UK	0	0	0	0	0	0	0	0	X	0	0
USA	0	0	0	0	0	0	0	0	0	X	0

Source: own elaboration.

Table 7A

Information matrix from 1 to 7 lags

LAG 7	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	1	0	0	0	0	0	0	0	0	1
CANADA	0	X	1	0	0	0	0	0	0	1	2
CHINA	0	0	X	0	0	0	0	0	0	0	0
FRANCE	0	0	0	X	0	0	0	1	0	0	1
GERMANY	1	1	1	0	X	0	0	0	0	1	4
INDIA	0	0	0	0	0	X	0	0	0	0	0
ITALY	0	0	0	0	0	0	X	0	0	1	1
JAPAN	0	0	1	0	0	0	0	X	0	0	1
UK	0	0	0	1	0	0	0	0	X	0	1
USA	0	0	0	0	0	0	0	0	0	X	0

Source: own calculation.

Table 8A

Information matrix from 1 to 8 lags

LAG 8	BRAZIL	CANADA	CHINA	FRANCE	GERMANY	INDIA	ITALY	JAPAN	UK	USA	SUM 1
BRAZIL	X	1	1	0	0	0	0	0	0	0	2
CANADA	0	X	0	0	0	0	0	0	0	1	1
CHINA	0	0	X	0	0	0	0	0	0	1	1
FRANCE	0	0	0	X	0	0	0	0	0	0	0
GERMANY	1	0	1	0	X	0	0	0	0	1	3
INDIA	0	0	0	0	0	X	0	0	0	0	0
ITALY	0	0	0	0	0	0	X	0	0	0	0
JAPAN	0	0	0	0	0	0	0	X	0	0	0
UK	0	0	0	0	0	0	0	0	X	0	0
USA	0	0	0	0	0	0	0	0	0	X	0

Source: own calculation.