DE GRUYTER OPEN

Folia Oeconomica Stetinensia
DOI: 10.1515/foli-2015-0011

WYDZIAŁ NAUK EKONOMICZNYCH I ZARZĄDZANIA
UNIWERSYTET SZCZECIŃSKI

THE INFLUENCE OF FINANCING ON THE DYNAMICS OF HOUSING PRICES

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Received 1 July 2014, Accepted 6 November 2014

Abstract

Real estate market can be thought of as an open, dynamic system. It means that it is able to exchange stimuli with other open systems, and that its state evolves in a way that might be described mathematically. It turns out that two main processes contribute to the overall evolution of the real estate market: long-term, predictable evolution, interrupted by sharp changes of catastrophic origin. In this picture, national housing funds play an important role in supporting the housing finance: on one hand they could either stimulate or suppress the real estate market influencing the availability of the mortgage credit, but on the other hand, they could also help to stabilize prices. In this study, an attempt was made to determine the degree of relationship between the volume of mortgage financing from national housing funds and the dynamics of real estate prices.

Keywords: housing market, market financing, system dynamics.

JEL classification: C51, R31, R32.

Introduction

Housing market is widely recognized a vital element of a market-driven economy and a factor influencing society's prosperity and satisfaction. According to Foryś[1], the property market together with its economic and social environment form a system of communicating vessels, in which stagnation in any segment and lacking communication between the segments have detrimental effect on the whole system.

Everyone, either directly or indirectly, is related to this market by taking up various activities concerning: buying, owning or renting a housing property. Owning a place to live is one of the fundamental human needs. According to Maslov's hierarchy of needs, housing satisfies basic physical requirements for safety and survival, as well as the needs for social contact, esteem and self-actualization. In addition, the housing fulfills a broad spectrum of the needs of higher order, which implies that the property market, where housing resources are transferred, affects the behavior of individuals as well as the entire society. As such, housing markets interact in a variety of ways with the rest of the economy. The factors responsible for driving house prices include, for example: income, the housing stock, demography, credit availability, interest rates and others. This is the reason, why the housing market is defined as the space, where housing services are allocated by the mechanisms of supply and demand. In Selim[2] opinion, the characteristics of the housing market differs from the goods and services markets in terms of the inelasticity of housing supply. Housing services belong to the most expensive household expenditures. Variations in housing prices attract great attention of individuals and governments due to their influence on the socio-economic conditions, and further on the overall national economic condition. Expectations of capital gains from housing investments affect housing prices by increasing the demand for housing, which in turn causes high volatility in housing prices.

Behaviors on the housing market are subject to change due to agglomerate fluctuations of internal and external determinants, thus leading to changes in the individual elements of the system. These changes, as well as the environment itself, constitute a multidimensional space in which uncertainty occurs. Even the smallest disturbance may evolve with elapsed time into significant change in other elements of the system, completely altering the relations and dependences occurring in the market[3].

In the light of the above facts, the housing market is composed of elements (*objects and entities*) connected with different relations (*buying, selling, renting*). All processes occurring in this set take place in well-defined periods of time, and their dynamics depend on the space-time scale of perturbations in the system's environment. Hence, the housing market can exchange signals with other systems (*open system*), and its evolution can be described using mathematical equations (*dynamical system*).

The major goal of this study is to determine the degree of relationship between the volume of mortgage financing from the government's subsidiary program "Family on its own" (in Polish: "Rodzina na swoim") national housing funds and the dynamics of real estate prices. This research makes use of models originally developed for description of physical phenomena, that is the model of critically-damped harmonic oscillator (CDHO), and the measures of concurrency.

This work presents results of an interdisciplinary research. According to Czaja[4], physical laws form a solid base for other scientific disciplines. In recent years, a number of papers has been published, which contribute to the so-called econophysics, for example: Mantegna and Stanley[5], Sinha[6], McCauley[7] and Perello[8], Gubiec[9], Kasprzak[10] etc.

1. Financing resources on the real estate market and the variability of real estate prices

Mortgage-subsidy programs, through which the government pays some percent of the interest on qualifying mortgages, contribute to popular schemes of financing of the housing market. Such programs are meant to enhance customer demand in the residential sector. Announced in 2007, the government's subsidiary program "Family on its own" aimed to assist young Poles in the purchase of their first housing property. Relationships between housing prices, and the volume of the government's subsidy (including the program "Family on its own") were deeply analyzed by various authors, among others: Foryś and Batóg[11], Gołąbeska[12], Kokot[13], Kubów[14], Majorek[15], Mastalerz[16], Wodniak[17].

In this study, an attempt is made towards an explanation of whether and how the discussed program affects the dynamics of housing prices on local real estate markets. Three cities, regarded as economic centers of their regions, were selected for detailed analyses: Warsaw in Mazovia Province (WAW, central Poland), Gdansk in Pomerania Province (GDN, northern Poland), and Szczecin in West Pomerania Province (SZZ, north-western Poland). The study period spans from 2007 until 2013. Figure 1 shows basic descriptive data, including time series of loan volumes, and the numbers of loans granted in local housing markets, together with transaction prices of housing properties.

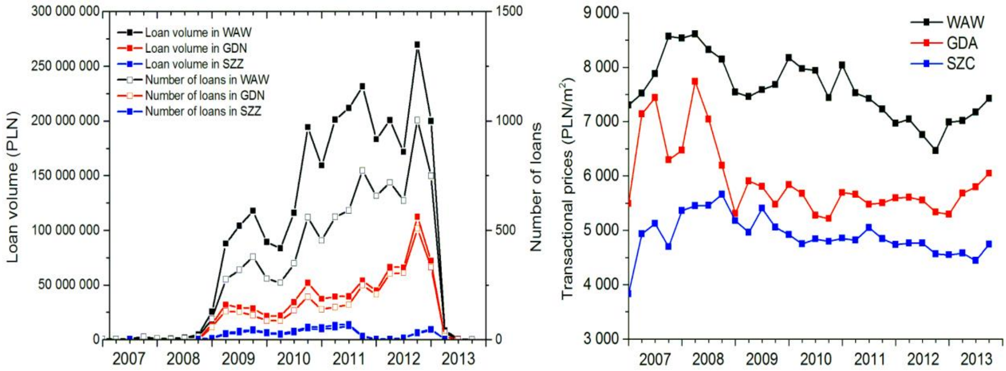

Fig. 1. Basic descriptive data of local housing markets containing time series of: loan volumes (closed squares), numbers of granted loans (open squares) (left), and transaction prices of housing properties (per square meter) (right)

Source: own study.

Left graph in Figure 1 exhibits dominant position of the housing market in Warsaw in terms of the volume as well as the number of granted mortgages, and the subordinated position of the market in Szczecin in that aspect. In general, presented plots show that the program "Family on its own" had raised rapidly increasing interest close to its expiration date. On the other hand, right graph in Figure 1 presents the endings of steep rises in housing prices, which began in 2006. The time period from 2006 until 2007 was the subject of our earlier analysis, where it was referred to as discontinuous transition[18], phase transition[19], or simply catastrophe[20]. Beyond this point the housing prices asymptotically relax to the equilibrium level depending on their volatility. In general, increasing numbers of loans in local housing markets go hand in hand with decreasing housing prices.

2. Delay analysis of time series of housing prices in local markets

Time series of the housing prices on local real estate markets can be successfully described using the equation of critically damped harmonic oscillator (CDHO), which serves as an example of simple dynamic system in physics. This model approximates a large variety of systems that vibrate or oscillate, such as a mass attached to a spring, a pendulum, or an electric current in an impedance circuit. The analogy between housing market and harmonic oscillator is drawn from observation that a steep rise in housing prices (housing bubble) is in fact a transient disturbance to otherwise stable price evolution, and is followed by an asymptotic return to a long-term equilibrium in a series of oscillations (system relaxation). What is important, even if the CDHO model itself is defined by a second-order differential equation, it has a strict analytical solution.

Non-linear regression allows empirical data (housing prices) to be fitted with the CDHO equation in the form:

$$y(t) = \left[A(t - t_0) + B \right] e^{-\left(\frac{t - t_0}{\tau}\right)} + y_{EQ} \quad (1)$$

where: t – denotes time, t_0 – absolute time delay, τ – relaxation time, y_{EQ} – long-term equilibrium level, e – Euler's number ($e \approx 2.72$), A and B – model constants depending on the initial conditions. These parameters are directly related to a time-dependent evolution of the studied system. Incorporated from physical sciences, CDHO model allows us to derive useful data on the behavior of the housing market using average housing prices.

In general, absolute time delay can be thought of as a difference between arbitrary initial time and the onset of a system evolution. The delay is necessarily introduced in the model, because each time series starts more or less randomly depending on the availability of statistical data. Regardless of whether it is observed or not, the system evolves continuously with elapsed time, and hence beginning of a time series cannot be taken as the absolute beginning of the evolution. In other words, absolute delay defines the shift of the series along the time axis, where positive and negative delays mean that the evolution goes after and before the beginning of the time series, respectively. In the current paper, absolute delay t_0 refers to a period of time between the beginning of a time series and the onset of the housing bubble. Similar t_0 values correspond to highly concurrent time series, in which housing bubbles happen roughly at the same time, whereas the smallest delay points at the market in a dominant position. Any event seen in the dominant market spreads over the network of open systems, and after specific time delay triggers similar events in other markets. This suggests that local housing markets form a system of communicating vessels.

Relaxation time τ establishes a period of time required for an observable to decrease to 1/e (0.368) of its initial value. The higher τ value, the slower system return to the equilibrium state. On the other hand, reciprocal relaxation time is associated with the system inertia and is responsible for its sensitivity to fluctuations in independent variables. In case of the housing market, relaxation time describes specific dynamics of time series of local housing prices. The markets characterized by lower τ values are found to be more sensitive to external stimuli, that is they exhibit larger price variations due to higher volatility. In turn, long-term equilibrium level y_{EQ} defines the asymptotic limit, to which the housing prices are approaching in a series of damped oscillations.

In Figure 2 results of a curve fitting procedure of CDHO model are plotted together with housing prices in local markets: Warsaw (WAW), Gdansk (GDN) and Szczecin (SZZ). The details of the model parameters, such as: the coefficient of determination R^2, absolute as well as specific time delays, t_0, and t_{spec}, respectively, and long-term equilibrium level y_{EQ} are all specified in Table 1.

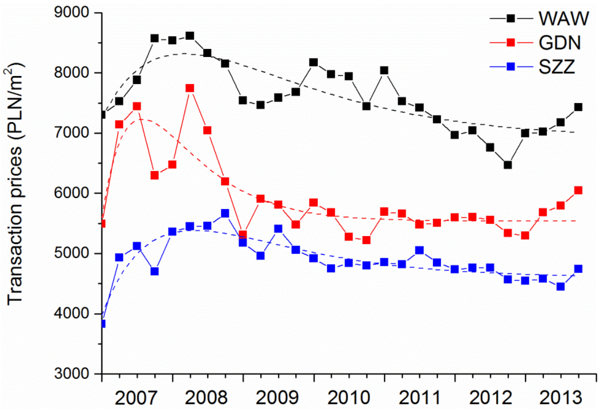

Fig. 2. Plots of transaction prices (per square meter) in local housing markets compared with results of numerical curve fitting in terms of CDHO model

Source: own study.

Table 1. The results of numerical fitting of the CDHO model to empirical data

	Symbol	WAW	GDN	SZZ
Coefficient of determination	R^2	0.61	0.62	0.70
Absolute time delay (quarters)	t_0	2.10	3.50	2.60
Specific time delay (quarters)	t_{spec}	0.00	1.40	0.50
Relaxation time (quarters)	τ	5.20	2.30	4.30
Long-term equilibrium price (PLN/m²)	y_0	6,912	5,537	4,600

Source: own study.

Obtained coefficient of determination varies between 0.6 and 0.7, indicating that the model quite good fits to the data. Considering absolute time delays, t_0, it is the housing market in Warsaw (WAW), which turns out to be dominant due to the lowest t_0 value (2.1 quarters, i.e. ca. 6 months). Housing prices in Szczecin (SZZ) exhibit specific time delay, t_{spec}, as small as a half of quarter (45 days) in reference to dominant market, which indicates their concurrence to the reference in terms of very small propagation delay of the bubble. In turn, the prices in Gdansk (GDN) are delayed around 1.4 quarters (4 months) to the reference, which suggests weak coupling of the housing market in Gdansk to that in Warsaw. In contrast, the housing market in Gdansk turns out to be the most volatile – housing prices return to the equilibrium level much faster than in Warsaw, and Szczecin due to the lowest relaxation time equal to 2.3 quarters (ca. 7 months). The market in Warsaw is found the least volatile in that aspect, since its relaxation time equals to 16 months. Finally, long-term housing prices per square meter in a stable equilibrium in Warsaw, Gdansk, and Szczecin are estimated at, respectively: 6,912 PLN (1,686 EUR), 5,537 PLN (1,350 EUR), and 4,600 PLN (1,122 EUR).

3. Concurrence analysis of housing prices and price limits for "Family on its own"

Another issue addressed in the work concerns analysis of whether or not the time series of housing prices, and price limits set by the government's program "Family on its own" are concurrent. Through this mortgage-subsidy program for first-time home-buyers, about 50 percent of the interest on qualifying mortgages are co-financed over the first eight years. The price limits determine, which housing properties are available for the program. Detailed methodology for constructing price limits in local housing markets is described elsewhere[21].

Figure 3 shows the time-dependent plots of transaction prices in local housing markets compared with price limits set for the mortgage-subsidy program "Family on its own". At first,

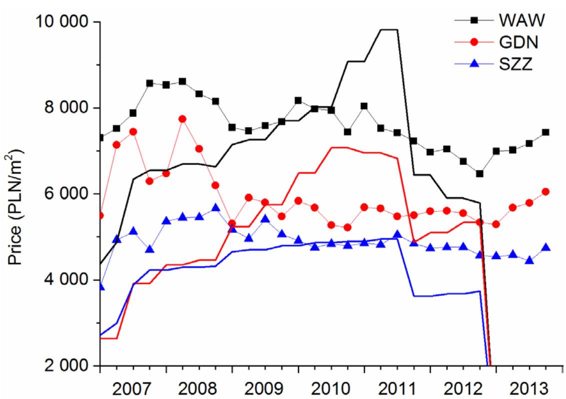

Fig. 3. Time series of transactional prices of housing properties (symbols) compared with the maximum housing price limits in the program "Family on its own" (solid line)

Source: own study.

large time shifts are seen between corresponding series, which suggest that the price limits are significantly delayed with respect to the housing prices. Such delays exhibit institutional inertia of the government in decision-making process, which might have detrimental influence on the overall housing market.

Figure 3 shows that the government gradually increased the price limits in the program until the middle of 2011, probably because it faced increasing pressure from developers. Unfortunately, this process failed to meet the most important events in the markets in terms of both steep rises, and subsequent relaxation of the housing prices. In addition, it is interesting to note that right after the program was closed at the end of 2012, observed housing prices started to go up simultaneously. It is therefore suggested that the price limits establish “the glass ceiling”, i.e. hardly visible barrier that keeps prices from rising to the upper levels.

To study to what degree the time series are concurrent, the following normalized correlation coefficient W_{12} is proposed:

$$W_{12}(t) = \frac{\langle (y_1(t) - \langle y_1 \rangle) \cdot (y_2(t) - \langle y_2 \rangle) \rangle}{\sigma^2} \tag{2}$$

where: t_0 – is the time shift between time series (y_1 taken as the reference), σ^2 – normalizing constant (variance), while <> denotes arithmetic mean. This coefficient is computed using circular correlation algorithm that makes use of periodic extension of the sequence followed by its circular wrapping. If the W_{12} coefficient approaches its maximum value, then the two series completely overlap, and are highly proportional (change in the same direction), otherwise such a linear dependency vanishes.

However, some attention must be paid when asymmetric sequences are taken into consideration, as in the studied problem. At its maximum, the correlation coefficient does not necessarily imply the best coincidence in characteristic features of the series (steep rises and deep falls). Hence, we propose to modify a standard measure of a delay between concurrent sequences and suggest using the difference between time shifts corresponding to $W_{12\max}$ and $W_{12\min}$ instead of that corresponding to $W_{12\max}$ alone.

Analysis of concurrency, despite difficulties in accurate evaluation of asymmetric sequences, exhibits significant delays of the price limits for the subsidiary program in reference to the housing prices equal to, respectively: around 4 years (WAW – 17 quarters), 3 years (GDN – 12 quarters), and about 2 years (SZZ – 7 quarters). Such large delays imply that corresponding time series are hardly concurrent, which is shown in Figure 5. Most importantly, the limits itself are found to influence the prices of new housing properties offered by developers, and hence these time series appear no longer independent.

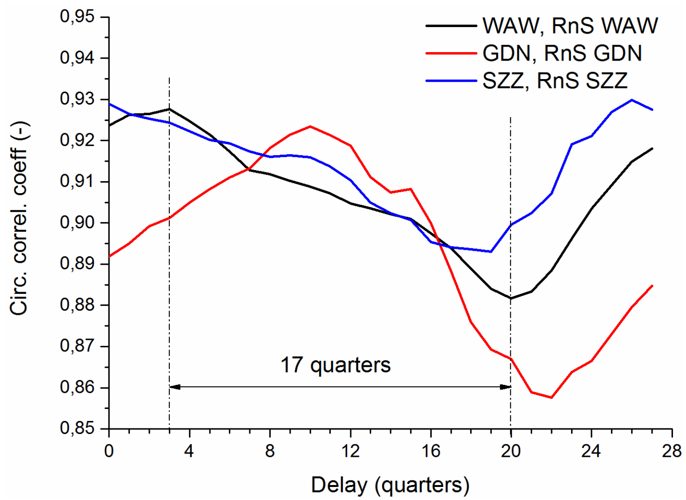

Fig. 4. Plots of circular correlation coefficient vs. delay time in local housing markets

Source: own study.

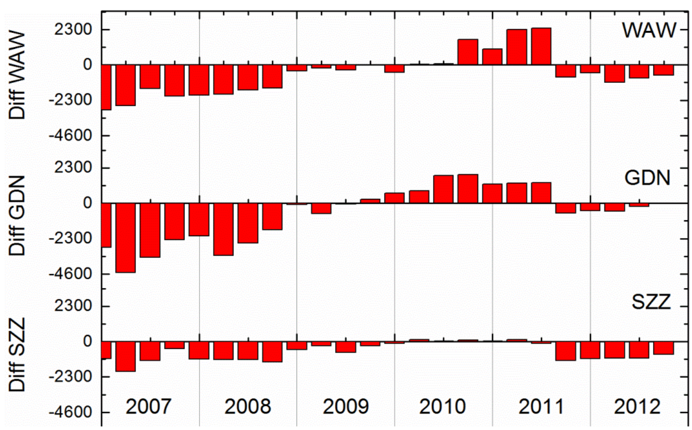

Fig. 5. Plots of differences between price limits set in the program “Family on its own” and transaction prices in local housing markets

Source: own study.

Figure 5 shows that in the beginning the price limits were largely underestimated with respect to the housing prices, then, after few modifications made to the program, they became overestimated, while at the end of the program, the limits were deeply reduced falling below the housing prices. Beyond that point sudden rise in the housing prices occurred, leaving behind long-term levels of equilibrium prices. In our opinion, the price limits for the subsidiary program turn out to be a key factor in a decision-making process of calculating of the housing prices by developers in the primary market. After its expiry in 2012, "the glass ceiling" disappeared, and the prices started to change. Such a suggestion is supported by lacking observation of similar increase in housing prices in the secondary market, excluded from the program.

Conclusions

This paper presents results of interdisciplinary research, which explores the benefits of applying the methods originally derived in Physics, and Mathematics into Economic Science. Obtained results shed new light on the evolution of the housing markets, regardless of classic analytical methods used so far.

According to our findings, housing markets turn out to have higher inertia than other economic systems, i.e. they are slow to change. Due to exogenous factors (aggregate macroeconomic fluctuations), housing prices increase by similar amounts after specific time delay in reference to dominant market in Warsaw. In turn, endogenous factors differentiate between relaxation time-constants and long-term equilibrium levels of the prices. As a result, the overall housing market can be thought of as a large system of communicating vessels in the form of a network, in which local housing markets are represented by critically damped harmonic oscillators, coupled on one end to external stimuli and to their neighbors on the other.

In accordance with physical laws obtained results suggest that the housing markets best reveal their inertial properties when they change suddenly. In short intervals of steep rises or sudden falls in housing prices, the markets are subjected to deep changes of structural origin, whereas otherwise quasi-stationary long-term evolution keeps the markets in equilibrium. On the other hand, analysis of time delays between sequences of housing prices in local markets leads to the conclusion that the market in Warsaw is in a dominant position, and plays a role of a trigger of sudden changes in the model depicted above. Because local housing markets are coupled to each other, they evolve in a concurrent manner. Apart from that, however, the price limits for the program are found to be significantly delayed with respect to housing prices due to institutional barriers in the decision-making process, and the limits itself appeared to influence the prices of new housing properties offered by developers in the primary market.

Acknowledgements

This work was supported by the grant from the National Science Centre (NCN) number DEC 2012/07/B/Hs4/03267.

Notes

1 Foryś (2011).
2 Selim (2009).
3 Radzewicz et al. (2011).
4 Czaja (1997).
5 Mantegna, Stanley (2001).
6 Sinha et al. (2010).
7 McCauley (2004).
8 Perello et al. (2008).
9 Gubiec et al. (2010).
10 Kasprzak et al. (2010).
11 Foryś, Batóg (2013).
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