HOUSE PRICE CONVERGENCE ON THE PRIMARY AND SECONDARY MARKETS: EVIDENCE FROM POLISH PROVINCIAL CAPITALS[1]

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Abstract

The aim of this study is to identify whether there is a common house price trend across provincial capitals in Poland. The log t regression is the main method of analysis. Additionally, traditional convergence tests based on the concepts of β- and σ-convergence are used. The obtained results indicate that the cities do not share a common price in the long-run. There are, however, convergence clubs on both primary and secondary markets. In each club, house prices across cities tend to converge to their own steady state. Moreover, research on the driving forces of convergence reports that factors affecting housing prices differ among the clubs. Therefore, policymakers should adjust housing policies in accordance with the characteristics of a given club. In turn, the σ-convergence model demonstrated a very interesting finding, namely, a U-shape pattern of convergence, both on the primary and secondary markets. This pattern is strictly correlated with the level of prices on the markets.

Key words: *log t regression, the housing market in Poland, σ-convergence, β-convergence, house price convergence.*

JEL Classification: *C10, R31, R32.*

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1. Introduction

The housing market plays a key role in shaping the economy both at the state and local levels. A very important part of the housing market is house prices that affect not only economic matters, but also labor mobility between regions and the affordability of housing (HOLMES et al. 2019). Therefore, knowledge of how house prices behave over time is crucial. A better understanding of a house price dynamics is helpful to national and local policymakers, as well as financial institutions. On this basis, many researchers study the convergence of housing prices, especially on the regional level. A leading role in this matter seems to be played by research in the UK and USA (HOLMES, GRIMES 2008; HOLMES et al. 2011; KIM, ROUS 2012; MONTAGNOLI, NAGAYASU 2015; HOLMES et al. 2019). Moreover, there is a rapid growth in studies on the convergence of regional house prices in China (ZHANG, MORLEY 2014; MENG et al. 2015; MAO 2016; CHOW et al. 2016). Studies on house price convergence are very often completed by an analysis of the impact of fundamental economic factors on convergence club membership.

This paper concerns the regional housing market in Poland where the problem of house price convergence has been insufficiently studied. There are only few research papers that test the

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convergence of regional house prices in Poland. For example, GNAT (2014) examined the convergence of local house prices in the Szczecin metropolitan area using β-, σ- and α-convergence models. DITTMAN (2014), in turn, carried out a study on the σ-convergence of house prices in Polish provincial capitals in the years 2007−2012. Based on previous research, it can be concluded that there is a research gap in terms of studying regional house price convergence in Poland. Consequently, the main aim of this paper is to examine whether there is a single long-term equilibrium to which investigated cities converge, or whether multiple equilibria (i.e. convergence clubs) exist. Moreover, in the case of the occurrence of convergence clubs, the second aim of this research is to identify key factors affecting house prices in each club using a fixed effects model. Due to the availability of data, I examine the convergence of house prices on the primary and secondary markets in Polish provincial capitals. The main method of the study is the log t convergence test introduced by PHILLIPS and SUL (2007) and additionally β- and σ-convergence models.

Prior to statistical analysis of house price convergence, the economic theory of housing prices will be presented. According to the model outlined by ROSEN (1979) and ROBACK (1982), house prices, population and wages across cities should adjust so that marginal residents of all locations receive identical utility. Theoretically, however, it is utility that should converge rather than house prices, so there is little theoretical support that housing prices should converge too (KIM, ROUS 2012). Yet, there are arguments why housing prices may share a single common component across cities. First of all, housing demand fundamentals, such as income or interest rates, may converge across regions (HIEBERT, ROMA 2010) and, as a consequence, lead to the convergence of house prices. Moreover, there are other factors, like capital mobility, contributing to regional house price convergence (CLARK, COGGIN 2009). In the case of Poland, it is very unlikely that all provincial capitals have similar economic fundamentals. This is due to the fact that Poland is divided into parts "A" and "B" in terms of economic development. Generally speaking, part "A" covers the western areas, and part "B" covers the eastern areas of the country. Therefore, common house prices in the long-run for all cities would be a very surprising finding. Conversely, there is a probability of finding some subgroups of cities with similar economic development, as well as existing convergence of prices on the housing market. If such a clustering exists, it is of interest to identify the driving forces of convergence in each club. Moreover, it is worth noting that the convergence of house prices across cities can be different on the primary and secondary market. Analysis of convergence clubs may reveal specific spatial relationships between cities. More specifically, it is likely to find groups of cities with a common price that are not located close to each other.

To summarize the main results of this research, using the log t convergence test, I found that house prices in Polish provincial capitals do not share a common trend in the long-run. This lack of convergence across cities led me to investigate convergence clubs. The clustering process indicates that there are multiple equilibria both on the primary and secondary markets. I also studied the driving forces of convergence in each club. The results confirmed that there is no single group of key economic factors that affect the house price trend in each group. This finding shows the complexity of the housing market in Poland and indicates that different housing policies should be implemented for each club. Moreover, in contrast to the results of the log t convergence test, the β-convergence model showed ultimate convergence across cities. In turn, the σ-convergence model demonstrated a very interesting finding, namely, a U-shape pattern of convergence both on the primary and secondary markets. This pattern is strictly correlated with the level of prices on the markets.

The remainder of the paper is structured as follows: Section 2 describes convergence tests, the data, as well as the results of the log t convergence test. It also shows the findings based on the β- and σ-convergence models. In Section 3, I investigate house price convergence clubs and the driving forces of convergence in each club, as well as present a discussion of the results. Section 4 reports the main conclusions of the study and indicates the possibility of future empirical research on the topic.

2. Identifying house price convergence

2.1. Traditional convergence tests

Traditional convergence tests can be divided into three categories. The first uses the so-called β-convergence. In the context of house prices in cities, this type of convergence examines whether cities with low initial house prices are characterized by higher house price growth rates. The presence of the β-convergence can be checked by a regression that takes the form (GOMLEKSIZ et al. 2017):

$$\frac{ln\left(\frac{p_{iT}}{p_{i0}}\right)}{T} = \gamma + \beta\, ln\, p_{i0} + \varepsilon_i \quad (1)$$

where: p_{iT} is house price of individual i at time T, p_{i0} is the initial house price of an individual i. The left part of the above equation represents the average house price growth rate. In the β-convergence model, a negative and significat slope coefficient in the regression represents an ultimate convergence. The β-convergence model allows us to determine a conditional convergence by completing Eq.(1) with a vector of control variables. This approach, however, has several shortcomings. First of all, the β-convergence model does not take into account a variety of house prices over time, because Eq.(1) is only a cross-secional regression. Moreover, the convergence parameter is biased and inconsistent due to omitted variables and endogeneity (BAI et al. 2019). The second classical approach of studying convergence is based on the so-called σ-convergence. This type of convergence is used to measure the cross-sectional standard deviation of house prices. If the value of standard deviation decreases over time, house prices tend to converge (SIMIONESCU 2014). The main disadvantage of this approach is that the so-called σ-convergence contains a little bit of information. The last approach is commonly defined as stochastic convergence. House prices across two cities converge stochastically if (PRÓCHNIAK, WITKOWSKI 2015):

$$\lim_{k\to\infty}\left(\ln p_{i,t+k} - \ln p_{j,t+k}\,|I_t\right) = 0 \quad (2)$$

where I_t represents the set of information at time t. Eq. (2) is fulfilled when a cointegrating vector [1,-1] exists for the series $\ln p_{it}$ and $\ln p_{jt}$. Thus, testing this type of convergence requires computing the following series:

$$d\ln p_{ijt} = \ln p_{it} - \ln p_{jt} \quad (3)$$

Then, the convergence is present if the $d\ln p_{ijt}$ series is stationary. For $N > 2$ cities the above time series is defined as:

$$d\ln p_{it} = \ln p_{it} - \overline{\ln p_t} \quad (4)$$

where $\overline{\ln p_t}$ is a cross-sectional average house price at time t. The stochastic approach assumes that individuals must be homogeneous which is not acceptable for testing convergence across cities.

2.2. Log *t* convergence test

Shortcomings of the traditional convergence tests have led researchers to look for new methods of testing convergence on the housing market. An innovative approach has been proposed by PHILLIPS and SUL (2007), who created the log t regression test. In comparison to the traditional tests, this method has the following advantages: it takes into consideration the heterogeneity among cities and allows this heterogeneity to change over time; it overcomes the problem of biased and inconsistent convergence parameters; it does not impose any special assumptions concerning trend stability or random non-stationarity; it allows the presence of convergence clubs to be analyzed if all cities do not share a common trend (BAI et al. 2019; DU 2017). In order to outline the details of the method introduced by PHILLIPS and SUL (2007), it is necessary to decompose $\ln p_{it}$ as follows:

$$\ln p_{it} = \left(\frac{g_{it}+a_{it}}{u_t}\right) u_t = \delta_{it} u_t \quad (5)$$

where g_{it} is permanent common components, a_{it} is transitory components, u_t is a single common component, δ_{it} is a time varying idiosyncratic component which is given as follows:

$$\delta_{it} = \delta_i + \left(\frac{\sigma_i}{\log(t)t^{\alpha}}\right)\xi_{it} \quad (6)$$

where δ_i and σ_i are fixed, $\log(t)$ is a slowly varying function, $\xi_{it} \sim iid(0,1)$, α is the convergence rate. With these assumptions, the authors construct the null hypothesis and alternative hypothesis for convergence as follows:

$$H_0\!: \delta_i = \delta \text{ and } \alpha \geq 0 \text{ vs. } H_A\!: \delta_i \neq \delta \text{ or } \alpha < 0 \quad (7)$$

The acceptance of the null hypothesis means that cities tend to converge. If H_0 is not accepted, convergence clubs may exist or the whole sample tends to diverge. Testing of H_0 is implemented in several steps. Firstly, the cross-sectional variance ratio H_1/H_t must be constructed using the formula:

$$H_t = N^{-1}\sum_{i=1}^{N}(h_{it}-1)^2 \tag{8}$$

where h_{it} denotes the relative transition parameter, which presents the transition path of city i in relation to the panel average at time t. h_{it} takes the form:

$$h_{it} = \frac{\ln p_{it}}{N^{-1}\sum_{i=1}^{N}\ln p_{it}} \tag{9}$$

When there is house price convergence across individuals, $h_{it} \to 1$ for all i, as $t \to \infty$. In the second step of testing the H_0 hypothesis, the following log t regression is started:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log(\log(t)) = a + b\log(t) + \varepsilon_t \tag{10}$$

where $t = [rT], [rT]+1, \dots, T$, with $r > 0$, $b = 2\alpha$. If $b \geq 2$, there exists an absolute convergence of house prices, whereas $2 > b \geq 0$ denotes a conditional convergence of house prices (Choi, Wang 2014). It is recommended to set $r = 0.3$ for $T \leq 50$ and $r = 0.2$ for $T \geq 50$.

In the last step of testing the H_0 hypothesis, the t-statistic t_b is checked. If $\hat{t_b} < -1.65$, the null hypothesis is rejected, which means that the whole sample does not converge and there is a possibility of existing convergence clubs, i.e. convergence in subgroups of the panel.

The algorithm of club clustering involves the following steps (Schnurbus et al. 2017; Du 2017; Holmes et al. 2019):

- Step 1: Extract the trend component from the data using a suitable filter.
- Step 2: According to the value of the last observation, order the cities in the panel in decreasing order. If high time series volatility is present in the data, sort individuals based on the average value of the last half of the sample.
- Step 3: Form core cities in the panel. To do this, run the log t regression for the k $(2 \leq k < N)$ highest cities and maximise t_k with $t_k > -1.65$.
- Step 4: To the core cities from step 3, add one city at a time and run the log t regression. If $t_k > -1.65$ for large T or $t_k > 0$ for small T, add the new city to the core group.
- Step 5: For the rest of the cities that fail step 4, run the log t regression and verify if $t_k > -1.65$. If true, the second club is obtained, if not, repeat steps 1 to 4 to check if the rest of the cities can be subdivided into smaller convergence clubs.
- Step 6: Try to merge initial clubs. For example, run the joint log t regression for the initial clubs 1 and 2. If the convergence hypothesis is fulfilled, merge the clubs. Then, run the joint log t regression for the new club and initial club 3. If the initial clubs 1 and 2 cannot be merged, try to perform the joint log t regression with the initial clubs 2 and 3. Continue the process until no clubs can be merged.

2.3. Data

In order to investigate house price convergence in this study, I use quarterly data from 2006:Q3 to 2018:Q3 on average flat prices per m² in Polish provincial capitals. The data are divided into two parts. The first includes flat prices on the primary market and the second - on the secondary market. The source of the data is the National Bank of Poland. The house prices series are used to perform the convergence tests after ln-transforming and extracting their trend component using the Hodrick and Prescott (1997) filter. In section 3, I use quarterly data from the Local Data Bank Statistics Poland to identify potential determinants of the convergence in each club. The following variables have been identified as such: number of flats under construction in a city with ground broken within a given quarter (Housing Starts), share of the unemployed in the population in a city in a given quarter (Unemployment Index), population density in a city in a given quarter (Population Density), area of a city in a given quarter (Area), house price in the previous quarter ($\ln p_{i,t-1}$). The chosen variables affect both supply and demand in the housing market and it is highly likely that they may significantly explain house price volatility in each convergence club.

2.4. Results of house price convergence

The first part of the empirical study investigates ultimate convergence across cities using β-convergence test. The results are presented in Table 1. On the primary market, the slope coefficient of the regression is equal to -0.009 and on the secondary market to -0.006, which indicates the presence of house price convergence in the data. On this basis, it is worth noting that the average house price growth rates are higher in cities with low initial prices compared to cities with high initial prices. The results obtained by the β-convergence test, however, do not imply a reduction of house price dispersion across cities over time. In order to check the above assumption, the σ-convergence test was conducted.

Table 1

The results of log t regression and β-convergence tests

	The primary market		The secondary market	
	Log t regression (r = 0.3)	β-convergence	Log t regression (r = 0.3)	β-convergence
Coefficient	−0.513	−0.009	−0.500	−0.006
t-statistic	−16.458	−4.980	−72.484	−4.685

Source: own study.

The results of the σ-convergence test show very interesting findings (see Fig. 1), namely, U-shape patterns over time both on the primary and secondary markets. These patterns suggest the rapid reduction of house price dispersion from the year 2006 to 2012. Next, reflections of the lines can be seen, which imply an increase in dispersion. These patterns are correlated with the level of prices on the markets. On this basis, one can say that the reduction of dispersion takes place in a period of falling house prices. Moreover, the primary market is much more sensitive to price changes.

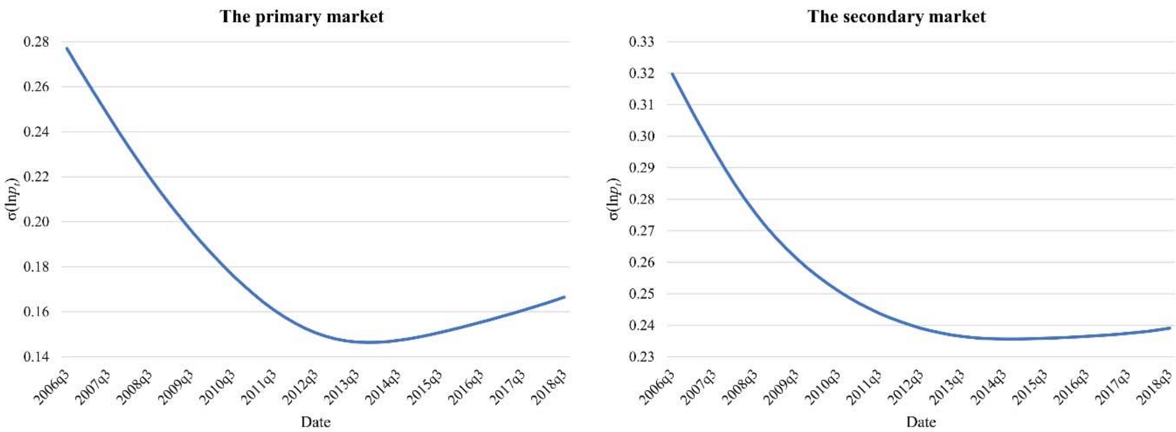

Fig. 1. The results of the σ-convergence test. *Source*: own study.

As had already been mentioned, however, traditional convergence tests have several shortcomings. Therefore, the log t regression was run to investigate house price convergence across the cities. A preliminary look at the results suggests that the cities do not share a common trend in the long-run, both on the primary and secondary markets ($\hat{t_b} = -16.458$ for the primary market and $\hat{t_b} = -72.484$ for the secondary market). It is of interest to look closer into the above finding by analyzing the relative transition curves.

Figure 2 indicates that there is cross-sectional and time-series heterogeneity in the data. In this regard, convergence tests based on the assumption of homogeneity are not appropriate for studying house price convergence across the cities. Analyzing the transition curves, some patterns can be observed. In particular, on the primary market, house price convergence from the year 2006 to 2012 ($h_{it} \rightarrow 1$ for all i, as $t \rightarrow \infty$) is present. Next, in the years 2012−2018, house prices tend to diverge. Moreover, some subgroups with a common trend are strongly marked. The secondary market has significantly more heterogeneity across the cities and there are no directly visible convergence subgroups. In summary, it is worth noting that the cities do not tend to converge to one common trend over time. Studying the patterns shown in Figure 1 and Figure 2, however, it is clear that there is evidence of convergence for the period 2006−2012 and for divergence in the years 2012−2018.

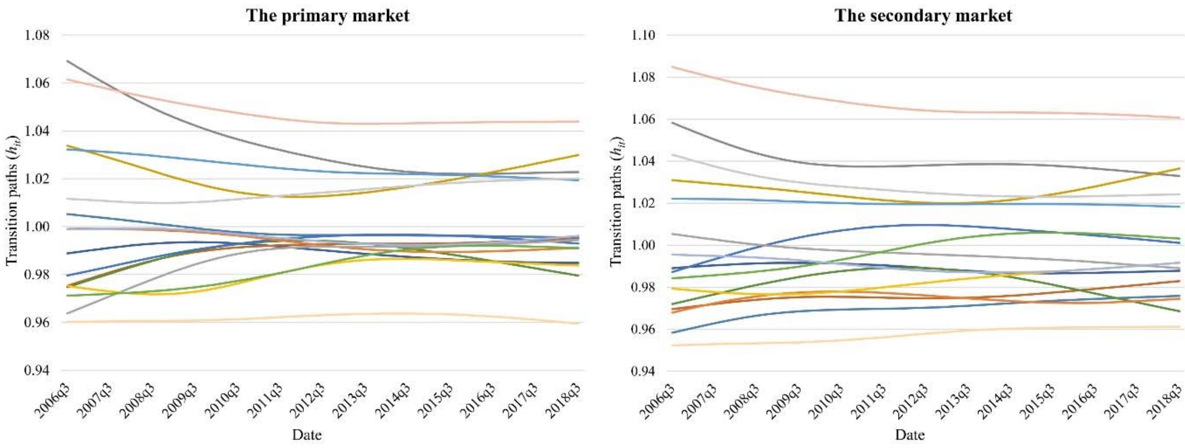

Fig. 2. The relative transition curves for the cities. *Source*: own study.

3. House price convergence clubs

3.1. Identifying the clubs

In Section 2, I found no convergence across the cities using the log *t* regression. There is, however, some evidence that subgroups of cities sharing a common price exist in the long-run. In order to identify these subgroups, I used the clustering algorithm proposed by PHILLIPS and SUL (2007). The algorithm has been described in detail in the previous section.

Table 2 presents the results of applying the clustering algorithm for the panel of cities. The initial classification indicates that there are three clubs in both the primary and secondary markets. The first club in the primary market includes the following cities: Gdańsk, Cracow, Poznań, Rzeszów, Warsaw and Wrocław. The presence of these cities in the first club is not surprising, except for the city of Rzeszów. This city is located in so-called Poland "B", which is less developed than Poland "A". Therefore, the example of the city of Rzeszów shows that it is possible to decrease disproportions between different cities even across areas "A" and "B". The second club in the primary market consists of seven cities and the third of three. Next, I tested club merging, but the results of log *t* regression indicated that the initial classification is simultaneously the final classification.

Table 2

Log *t* regression results: classification of convergence clubs

	Initial classification				Test of club merging		
	Club	Coeff.	t-stat.	Member cities	Club	Coeff.	t-stat.
The primary market	[1]	0.164	3.788	Gdańsk, Cracow, Poznań, Rzeszów, Warsaw, Wrocław	[1]+[2]	−0.312	−9.428
	[2]	0.467	4.934	Bydgoszcz, Katowice, Lublin, Olsztyn, Opole, Szczecin, Łódź	[2]+[3]	−0.496	−13.027
	[3]	0.113	2.932	Białystok, Kielce, Zielona Góra			
The secondary market	[1]	0.130	4.018	Cracow, Warsaw, Gdańsk	[1]+[2]	−0.194	−26.733
	[2]	0.244	18.042	Lublin, Opole, Poznań, Rzeszów, Wrocław	[2]+[3]	−0.412	−55.545
	[3]	0.083	2.281	Białystok, Bydgoszcz, Katowice, Kielce, Olsztyn, Szczecin, Zielona Góra, Łódź			

Source: own study. *Notes*: The results indicate that there exists a conditional convergence in each club.

In the secondary market, the allocation of cities to clubs is quite similar to that of the primary market. There are, however, some significant differences. First of all, the first club consists of only three cities: Cracow, Warsaw and Gdańsk. These cities are very well developed in economic and touristic terms. The latter may lead to convergence of house prices because flats in the secondary market are very often located close to the city center, so high tourist traffic significantly increases their value. The rest of the cities in the secondary market are allocated as follows: club 2 – Lublin, Opole, Poznań, Rzeszów and Wrocław, club 3 – Białystok, Bydgoszcz, Katowice, Kielce, Olsztyn, Szczecin, Zielona Góra and Łódź. It is of interest that cities with a common trend are not always located close to each other (see Fig. 3 and Fig. 4).

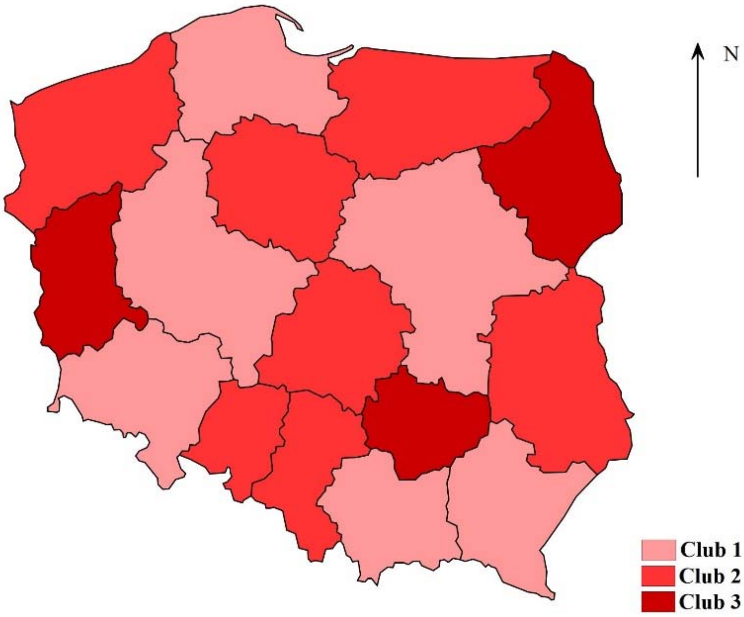

Fig. 3. The convergence clubs in the primary market. *Notes*: to better illustrate the spatial distribution of the cities, whole provinces are marked instead of their capitals. *Source*: own study.

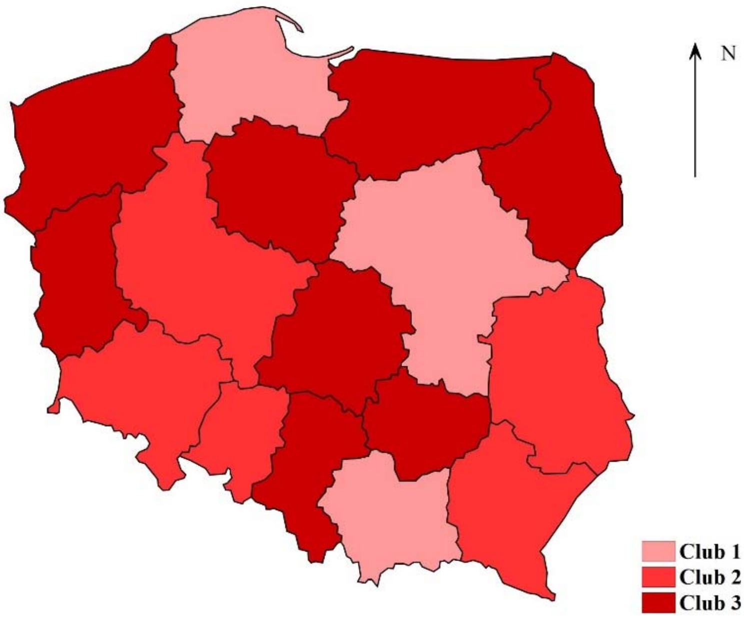

Fig. 4. The convergence clubs in the secondary market. *Notes*: to better illustrate the spatial distribution of the cities, whole provinces are marked instead of their capitals. *Source*: own study.

Completing the analysis of house price convergence clubs, it is also worth discussing the transitional dynamics of house prices in each convergence club. I therefore calculated the relative transition curves for the clubs as follows:

$$h_{s,it} = \frac{\ln p_{s,it}}{N_s^{-1}\sum_{i=1}^{N_s} \ln p_{s,it}} \tag{11}$$

where $s = 1, \ldots, 3$, N_s denotes the number of cities in club s. The results of studying transitional dynamics suggest cross-sectional and time-series heterogeneity across the cities in each club (see Fig. 5). House prices in the primary market, however, appear to narrow toward unity over time much more than house prices in the secondardy market. Moreover, some clubs include strongly visible subclubs of cities. This can be observed, for example, in club 2 in the secondary market, where Poznań and Wrocław form subclub 1, and Opole, Rzeszów and Lublin form subclub 2. Analyzing Figure 5, another interesting finding can be seen in regards to club 2 in the primary market, namely, the relative transition curve for the City of Opole. From the year 2006 to 2009, a phase of divergence from the club is observed for this city, and next, the curve tends to narrow toward unity. From the year 2015, however, a slight deviation of the curve from unity is again visible.

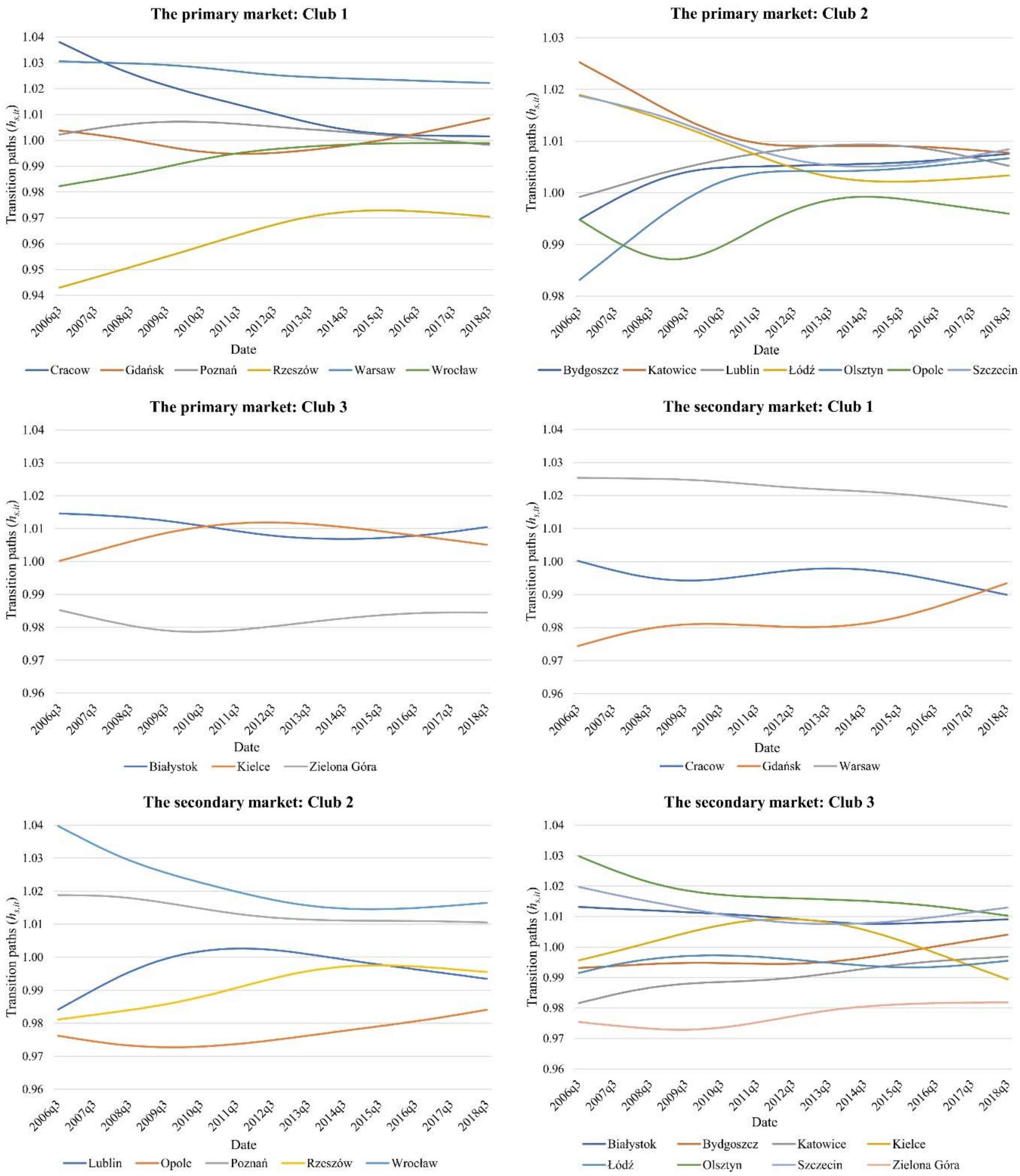

Fig. 5. Transition paths in the clubs. *Source*: own study.

3.2. Driving forces of the convergence

In the previous subsection, I have shown that house prices across the cities do not converge to a common trend. In particular, there exist so-called convergence clubs, where house prices converge to a common price in the long-run. Therefore, it is of interest to identify the possible forces of convergence in each identified subgroup. For this purpose, the approach outlined by LIN et al. (2015), WANG et al. (2011), LI and CHAND (2013), ZHU et al. (2018) was applied, which is based on a dynamic panel model. However, the presence of a lagged dependent variable as a regressor leads to biased estimates. In order to avoid this problem, I decided to use the second-order lagged dependent variable as the instrumental variable (GALVAO 2011).

In the first step of studying the driving forces of the convergence, I conducted the stationarity test of each variable. I used LEVIN et al. (2002), IM et al. (2003), BREITUNG and DAS (2005) tests. The results of these tests indicated that all variables are stationary at level or first difference (options of each test were selected after testing the potential presence of cross-sectional dependence in the data). Then, panel cointegration tests (in particular, PEDRONI (2004) and WESTERLUND (2007) tests) were used to check whether there is a long-run cointegration relationship among variables. The results of these tests indicated that there is a long-run equilibrium relationship among variables in each club.

It should be emphasized that, according to the author's knowledge, no econometric research has been conducted thus far on the identification of the driving forces behind convergence in the housing market in Poland. BALDOWSKA et al. (2014) have undertaken preliminary studies on the subject by presenting potential convergence factors. The authors classified these factors into the following groups describing: the housing situation, scale of construction, housing prices, economic factors and demographic factors. In this paper, however, it was not possible to take all of the factors presented by BALDOWSKA et al. (2014) into account because of the quarterly nature of the data.

In order to explain the volatility of the dependent variable, the factors affecting both demand and supply in the housing market were used (a detailed description of the variables is provided in section 2.3). The results of the estimation are presented in Table 3. The type of each panel data model was selected based on HAUSMAN (1978) as well as BREUSCH and PAGAN (1980) tests.

Table 3

The driving forces of convergence in the clubs

	The primary market			The secondary market		
Club	[1]	[2]	[3]	[1]	[2]	[3]
Variable	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
$\ln p_{i,t-1}$	0.449*	0.595***	0.485**	0.881***	0.745***	0.922***
$\ln p_{i,t-2}$	−0.058	0.076	0.102	−0.190**	−0.137*	−0.109
ln(Unemployment Index)	−0.087**	−0.041***	−0.059*	−0.056***	−0.031**	−0.019***
ln(Housing Starts)	0.004	0.009**	0.001	0.009	−0.001	0.004
ln(Population Density)	1.117	0.027**	0.417	−0.058	0.263	0.022**
ln(Area)	1.088	0.015*	0.364	0.192**	0.315	0.005
R^2	0.78	0.73	0.59	0.95	0.88	0.83
Type of the model	FE	POLS	FE	POLS	FE	POLS

Notes: the dependent variable is a ln-transformed average flat price per m² in a city in a given year ($\ln p_{it}$). ***One percent level of significance. **Five percent level of significance. *Ten percent level of significance. FE – fixed effects, POLS – pooled OLS. [1], [2], [3] – the number of a given club according to Table 2. The variable describing the level of gross salaries has not been included in the models because, both in the primary and secondary markets, there is a negative relationship between house prices and gross salaries (see Fig. 6 – the example of the city of Szczecin in the secondary market). This result is quite unexpected, because income is usually the key factor determining house price growth. In this case, I decided to skip this variable in the models. Regressions with robust standard errors.

Source: own study.

In general, the results indicate that historical house prices ($\ln p_{i,t-1}$), which reflect house price expectations, significantly influence house prices in each club. A similar situation is present in the case of a variable concerning unemployment, namely, the smaller the share of unemployed people in the population, the higher the house prices. The above negative relationship between the variables is natural because a decrease in unemployment leads to an increase in the purchasing power of the population.

The models also indicate that the Population Density variable has a positive impact on house prices. This situation is intuitive because an increase in population density positively affects demand on the housing market, which leads to an increase in house prices.

The area of a city is the next variable which significantly determines house prices in some clubs. The impact turned out to be positive. This may follow from the fact that a higher amount of land causes an increase in new housing investments, which leads to an increase in real estate turnover on local housing markets.

Furthermore, in one club, breaking ground on new housing units has a positive impact on flat prices. It could be assumed that an increase in supply would result in a fall in prices. The positive impact of the above-mentioned variable, however, is present in a housing market with very high real estate turnover, where there is huge lack of residential properties and new flats are sold very quickly. In this case, new housing investments may cause an increase in house prices.

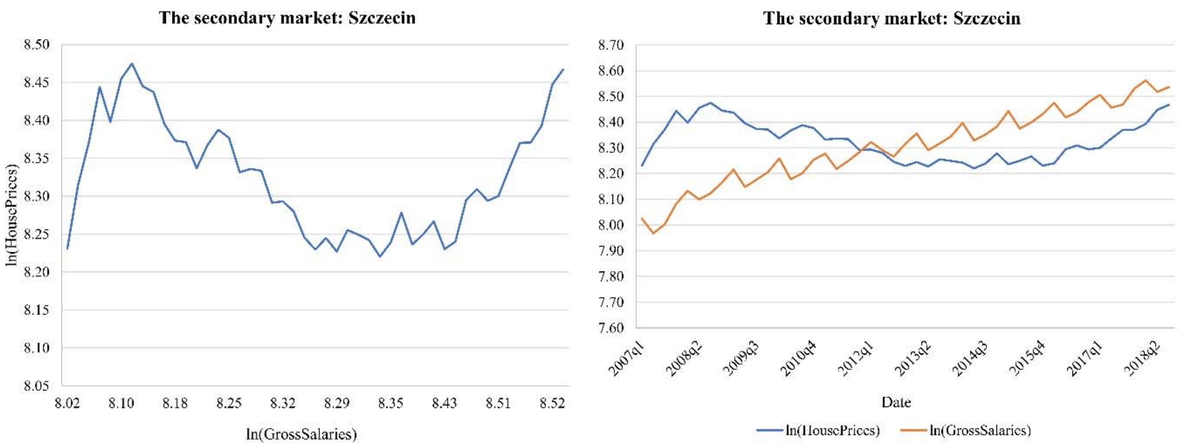

Fig. 6. The relationship between house prices and gross salaries in the city of Szczecin (the secondary market). *Source*: own study.

The results of the estimation show that both the primary and secondary markets in Poland are not homogeneous in terms of the driving forces of the convergence, which indicates the complexity of the housing market in Poland. Therefore, when defining housing policy, one should take into account not only the type of market but also the convergence clubs present in it.

4. Discussion and conclusions

In this paper, I have shown that house prices in the provincial capitals of Poland do not share a common trend in the long-run, according to the log *t* regression. There are, however, some subgroups of cities where house prices tend to converge both in the primary and secondary markets. Moreover, the driving forces of convergence are not the same in each convergence club. The above finding indicates the complexity of the housing market in Poland and the need to adapt the housing policy to each club.

In addition to the log *t* regression, the classical approach was used to study house price convergence across the cities. In particular, very interesting results have been found using the σ-convergence test, namely, U-shape patterns of house price standard deviation over time both in the primary and secondary markets. These patterns indicate that the primary market is much more sensitive to changes in the housing market.

To the best of the author's knowledge, this is the first paper that examines house price convergence across provincial capitals in Poland using the log *t* regression. Future research on this topic should take into consideration longer time series of house prices (if available). Moreover, the study of house price convergence on the provincial, county or commune level is another interesting proposition in terms of future research. Such research could contribute to a better understanding of the housing market in Poland, which remains not fully explored to date.

5. References

BAI C., MAO Y., GONG Y., FENG C., 2019, *Club convergence and factors of per capita transportation carbon emissions in China*, Sustainability, no. 11, 539.

BALDOWSKA G., LESZCZYŃSKI R., MYSZKOWSKA B., 2014, *Convergence and differentiation processes in local markets and structural changes (comparison of 16 markets in Poland)*, NBP Working Paper, no. 174.

Bank Danych Lokalnych GUS, 15.01.2019 (the Local Data Bank Statistics Poland, 15.01.2019). Online: https://bdl.stat.gov.pl/BDL/dane/podgrup/temat.

BREITUNG J., DAS S., 2005, *Panel unit root tests under cross-sectional dependence*, Statistica Neerlandica, no. 59, pp. 414-433.

BREUSCH T.S., PAGAN A.R., 1980, *The Lagrange multiplier test and its applications to model specification in econometrics*, Review of Economic Studies, no. 47, pp. 239-253.

CHOI C.Y., WANG X., 2014, *Discontinuity of output convergence within the United States: Why has the course changed*, Economic Inquiry, no. 53 (1), pp. 49-71.

CHOW W.W., FUNG M.K., CHENG A.C.S, 2016, *Convergence and spillover of house prices in Chinese cities*, Applied Economics, no. 48 (51), pp. 4922-4941.

CLARK S.P., COGIN T.D., 2009, *Trends, cycles and convergence in U.S. regional house prices*, The Journal of Real Estate Finance and Economics, no. 39 (3), pp. 264-283.

DITTMAN I., 2014, *Gamma konwergencja cen na lokalnych rynkach mieszkaniowych w Polsce (Gamma-convergence of prices on local housing markets in Poland)*, Studia Ekonomiczne (Economic Studies), no. 181, pp. 195-207.

DU K.R., 2017, *Econometric convergence test and club clustering using Stata*, Stata Journal, no. 17, pp. 882-900.

GALVAO A.F., 2011, *Quantile regression for dynamic panel data with fixed effects*, Journal of Econometrics, no. 164, pp. 142-157.

GNAT S., 2014, *Konwergencja cenowa na lokalnych rynkach nieruchomości w aglomeracji szczecińskiej w latach 2008–2013 (Price convergence of local property market in Szczecin metropolitan area in 2008-2013)*, Studia i Prace WNEiZ US (Studies and Works of the Faculty of Economics and Management University of Szczecin), no. 36 (1), pp. 213-225.

GOMLEKSIZ M., SAHBAZ A., MERCAN B., 2017, *Regional economic convergence in Turkey: does the government really matter for?*, Economies, no. 5 (3), 27.

HAUSMAN J.A., 1978, *Specification tests in econometrics*, Econometrica, no. 46, pp. 1251-1271.

HIEBERT P., ROMA M., 2010, *Relative house price dynamics across euro area and US cities: Convergence or divergence*, ECB Working Paper, no. 1206.

HODRICK R.J., PRESCOTT E.C., 1997, *Postwar U.S. business cycles: an empirical investigation*, Journal of Money, Credit and Banking, no. 29 (1), pp. 1-16.

HOLMES M.J., GRIMES A., 2008, *Is there long-run convergence among regional house prices in the UK?*, Urban Studies, no. 45 (8), pp. 1531-1544.

HOLMES M.J., OTERO J., PANAGIOTIDIS T., 2011, *Investigating regional house price convergence in the united states: evidence from a pair-wise approach*, Economic Modelling, no. 28 (6), pp. 2369–2376.

HOLMES M.J., OTERO J., PANAGIOTIDIS T., 2019, *Property heterogeneity and convergence club formation among local house prices*, Journal of Housing Economics, no. 43, pp. 1-13.

IM K.S., PESARAN M.H., SHIN Y., 2003, *Testing for unit roots in heterogeneous panels*, Journal of Econometrics, no. 115, pp. 53-74.

KIM Y.S., ROUS J.J., 2012, *House price convergence: Evidence from US state and metropolitan area panels*, Journal of Housing Economics, no. 21 (2), pp. 169-186.

LEVIN A., LIN C.F., CHU C.S.J., 2002, *Unit root tests in panel data: Asymptotic and finite-sample properties*, Journal of Econometrics, no. 108, pp. 1-24.

LI Q., CHAND S., 2013, *House prices and market fundamentals in urban China*, Habitat International, no. 40, pp. 148-153.

LIN R., ZHANG X., LI X., DONG J., 2015, *Heterogeneous convergence of regional house prices and the complexity in China*, Proceedings of Rijeka Faculty of Economics, no. 33 (2), pp. 325-348.

MAO G., 2016, *Do regional house prices converge or diverge in China*, China Economic Journal, no. 9 (2), pp. 154-166.
MENG H., XIE W.J., ZHOU W.X., 2015, *Club convergence of house prices: Evidence from China's ten key cities*, International Journal of Modern Physics B, no. 29 (24), 1550181.
MONTAGNOLI A., NAGAYASU J., 2015, *UK house price convergence clubs and spillovers*, Journal of Housing Economics, no. 30 (C), pp. 50-58.
Narodowy Bank Polski, 15.01.2019 (the National Bank of Poland, 15.01.2019). Online: https://www.nbp.pl/home.aspx?f=/publikacje/rynek_nieruchomosci/index2.html.
PEDRONI P., 2004, *Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis*, Econometric Theory, no. 20 (3), pp. 597-625.
PHILLIPS P.C., SUL D., 2007, *Transition modelling and econometric convergence tests*, Econometrica, no. 75, pp. 1771-1855.
PRÓCHNIAK M., WITKOWSKI B., 2015, *Stochastic convergence of the European Union countries: A conditional approach*, Annals of the Collegium of Economic Analysis, no. 39, pp. 41-55.
ROBACK J., 1982, *Wages, rents, and the quality of life,* Journal of Political Economy, no. 90 (6), pp. 1257-1278.
ROSEN S., 1979, *Wages-based indexes of urban quality of life*, pp. 74-104, in: *Current Issues in Urban Economics*, Johns Hopkins University Press, Baltimore.
SCHNURBUS J., HAUPT H., MEIER V., 2017, *Economic transition and growth: a replication*, Journal of Applied Econometrics, no. 32 (5), pp. 1039-1042.
SIMIONESCU M., 2014, *Testing sigma convergence across EU-28*, Economics & Sociology, no. 7 (1), pp. 48-60.
WANG Z., YANG Z., LIU H., 2011, *Impact of urban economic openness on real estate prices: Evidence from thirty-five cities in China*, China Economic Review, no. 22, pp. 42-54.
WESTERLUND J., 2007, *Testing for error correction in panel data*, Oxford Bulletin of Economics and Statistics, no. 69 (6), pp. 709-748.
ZHANG F., MORLEY B., 2014, *The convergence of regional house prices in China*, Applied Economic Letters, no. 21 (3), pp. 205-208.
ZHU H., LI Z., GUO P., 2018, *The impact of income, economic openness and interest rates on housing prices in China: Evidence from dynamic panel quantile regression*, Applied Economics, no. 50 (38), pp. 4086-4098.