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FORECAST ACCURACY AND SIMILARITIES IN THE DEVELOPMENT OF MEAN TRANSACTION PRICES ON POLISH RESIDENTIAL MARKETS

Abstract: This article presents the results of a study concerning the forecasting of mean transaction prices per 1 m^2 in eight residential markets in Poland. The first research problem was an attempt to study the dependencies between the similarity of price development between these markets and the values of the errors of price forecasts that were constructed based on this similarity. The analysis showed a lack of a negative linear relationship. This means that a greater similarity in price development in different markets did not allow for the construction of forecasts with a smaller error. The second research problem was a construction of global mean price forecasts. The results showed that the proposed method of constructing global forecasts was, compared to the traditional one, better in the case of some markets, and worse for others.

Keywords: shape similarity, forecasting, residential market.

1. Introduction

In several papers [Dittmann 2011a, b; Dittmann 2012a, b], the existence of temporal-spatial analogies concerning the development of mean transaction prices that exist in local residential markets was shown (Table 1). To this end, a measure of shape similarity was used [Cieślak, Jasiński 1979]. The threshold value (which represents an acceptably high similarity) was specified to be 0.5. It was also shown that a convergence of mean prices occurs in local residential markets [Dittmann 2012a].

This formed the groundwork for an attempt to use analogue methods for forecasting mean prices in these markets. The results obtained from this are contained in the paper [Dittmann 2012b]. In this paper it was shown that for six out of eight studied cities[1] (Warsaw, Gdańsk, Kraków, Wrocław, Łódź and Białystok) it was possible to construct mean price forecasts that had small errors. In addition, one of the issues considered in this paper was the existence of a dependency between the

[1] These are the largest residential markets in Poland: Warsaw, Gdańsk, Poznań, Kraków, Wrocław, Łódź, Katowice, Białystok.

Table 1. Converging, leading and following markets with respect to price per 1 m^2

Local markets	Local markets				
	leading by 2 quarters	leading by 1 quarter	converging	following (with 1 quarter lag)	following (with 2 quarters lag)
Warszawa	–	Wrocław (0.694; 0.678; 0.66)	Łódź (0.705; 0.696; 0.681; 0.663)	Kraków (0.671; 0.654; 0.635)	–
Wrocław	Katowice (0.674; 0.657)	–	Gdańsk (0.615; 0.595; 0.574; 0.551). Poznań (0.515;0.59; 0.569;0.546)	Warszawa (0.694; 0.678; 0.66)	Kraków (0.787; 0.775)
Białystok	Poznań (0.667;0.759). Katowice (0.661; 0.643)	Gdańsk (0.764; 0.751; 0.738). Wrocław (0.565; 0.542; 0.516)	–	Kraków (0.747; 0.734; 0.719)	Łódź (0.535; 0.51)
Poznań	–	–	Katowice (0.518; 0.593; 0.572; 0.549). Wrocław (0.515; 0.59; 0.569; 0.546)	–	Białystok (0.667;0.759)
Katowice	–	–	Poznań (0.518; 0.593; 0.572; 0.549)	–	Wrocław (0.674; 0.657). Gdańsk (0.663; 0.644) Białystok (0.661; 0.643) Kraków (0.549; 0.521)
Gdańsk	Katowice (0.663; 0.644)	–	Wrocław (0.615; 0.595; 0.574; 0.595)	Białystok (0.764; 0.751; 0.738)	Kraków (0.696; 0.679)
Kraków	Wrocław (0.787; 0.775). Gdańsk (0.696; 0.679). Poznań (0.549; 0.634). Katowice (0.549; 0.521)	Białystok (0.747; 0.734; 0.719). Warszawa (0.671; 0.654; 0.635)	Łódź (0.682; 0.672; 0.655; 0.636)	–	–
Łódź	Białystok (0.535;0.51)	Wrocław (0.595; 0.574; 0.55)	Warszawa(0.705; 0.696; 0.681; 0.663). Kraków (0.682; 0.672; 0.655; 0.636)	–	–

Source: [Dittmann 2012a].

values of the measure of similarity and forecast accuracy. It would seem that a greater similarity in the development of prices in various markets should coincide with small errors of price forecasts constructed for these markets. Therefore, the correlation between the two variables should be a negative one. The research conducted shows that, contrary to expectations, there is no statistically significant negative correlation between the values of the shape similarity measure and the values of the errors of the previously constructed forecasts. The value of the calculated correlation coefficient in the case of forecasts for one quarter into the future was positive and had a value of 0,19, while in the case of forecasts for two quarters into the future the coefficient was negative and had a value of –0.13. At the specified level of significance $\alpha = 0.05$ both correlation coefficients were statistically insignificant.

In the work mentioned above, an attempt was made to explain the results, among others, by saying that similarity is usually studied *ex post*. It is a similarity in the past and not in the future (and because of that it does not have to be reflected in forecast accuracy). Other possible causes are a time series adopted for studying similarity or a longer period of price stability that existed on all studied local markets (in the latter quarters there was presumably a larger shape similarity between all the cities – cf. Figure 1). It was also underlined that the existence of a dependency between the strength of similarity and the size of the forecasting error was studied on a limited interval of the similarity measure (larger than 0.5).

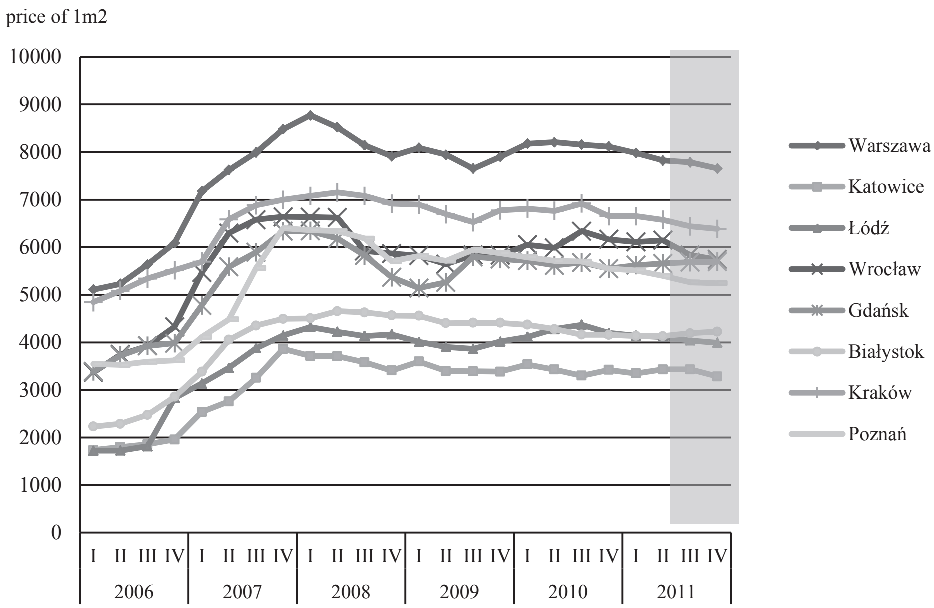

Figure 1. The mean transaction prices per 1 m^2 of floor area in chosen local residential markets (I quarter of 2006–IV quarter of 2012) in zł. The quarters for which forecasts were constructed are marked against a gray background

Source: own work based on data from [*Raport*… 2010, 2011].

The study presented in this paper is a continuation of the above-mentioned discussion. Specifically, an attempt was made in this paper to study the homogeneity of the sample. A suggestion was made that perhaps only in some cases (cities) the strength of the cities' similarity (for those that a forecast was constructed and which formed the basis of forecast construction) did not affect the size of the errors of the *ex post* constructed forecasts.

The aim of this study was an attempt to answer the two following questions:

1. Can we identify specific cities among those studied, where a negative correlation of the shape similarity measure with the *ex post* errors of the constructed forecasts existed, and can we also identify cities where such a correlation did not take place?
2. Does replacing shape similarity measures as weighting factors with ex post errors of forecasts expired for the construction of global forecasts, improve the accuracy of forecasting?

In order to answer the posed questions, use was made of some of the results obtained earlier [Dittmann 2011, Dittmann 2012b]. New research was conducted for measures larger than 0, that is for a larger range of values of the shape similarity measure.

2. Correlation between the similarity measure and the errors of *ex post* transaction price forecasts

In the previous study it was shown that there exists a one, two or three quarter lag in the development of mean transaction prices in the considered local markets. In this study only a one quarter lag was taken into account. In this way, 56 observations of the value of the similarity measure were obtained (Table 2). The calculated values of the measure were contained in the interval from –0.099 to 0.738. Most values were contained in the interval (0.3–0.4) (Figure 2). Next, using the analogue method [Cieślak, Jasiński 1979, Dittmann 2011] 14 forecasts were constructed for each city, based on prices in leading local markets (7 forecasts for the next quarter, i.e. 3rd quarter of 2011 and 7 forecasts for two quarters into the future, i.e. the 4th quarter of 2011). These were partial forecasts. For these forecasts *ex post* percentage errors were calculated (Table 3) and correlation plots were constructed (Figures 2, 3). Accurate forecasts were taken as those where the *ex post* error was no greater than 5%. It may be claimed that almost all partial forecasts for the 3rd quarter of 2011 were accurate (4 were inaccurate). In the case of forecasts for the 4th quarter of 2011, 11 partial forecasts (out of 56) can be said to be inaccurate. If the threshold error value was assumed to be 10%, all forecasts constructed for the 3rd and 4th quarters of 2011 would have been accurate.

The values of the correlation coefficient calculated for the similarity measures and the forecast errors were negative yet rather small. They were –0.23 for forecasts constructed for the 3rd quarter of 2011 and –0.16 for forecasts for the 4th quarter of 2011. This signifies a weak linear correlation.

Due to the rather small values of the correlation coefficients, the next step was to check whether, among the studied cities, there are those that disturb the expected

Table 2. Shape similarity measure values

Following markets	Leading markets							
	Warszawa	Katowice	Łódź	Wrocław	Gdańsk	Białystok	Kraków	Poznań
Warszawa	X	0.443	**0.554**	**0.66**	0.226	**0.508**	0.415	**0.55**
Katowice	0.104	X	0.436	0.328	0.343	0.181	0.338	0.214
Łódź	**0.553**	0.334	x	**0.55**	0.116	0.4	0.306	0.44
Wrocław	0.329	0.107	0.222	x	0.34	0.19	0.122	0.22
Gdańsk	0.329	**0.537**	-0.002	0.097	x	0.022	-0.099	0.435
Białystok	0.324	0.322	0.238	0.516	**0.738**	x	0.323	**0.616**
Kraków	**0.635**	0.237	0.528	0.418	0.411	**0.719**	x	0.522
Poznań	0.114	0.316	0.223	0.321	0.334	0.223	0.082	x

Source: own calculation [Dittmann 2012a].

Table 3. *Ex post* errors of partial forecasts (in %)

Following market	Leading market	*Ex post* error 3Q2011	*Ex post* error 4Q2011
Warszawa	Katowice	–1.6	–3.3
	Łódź	–0.2	–0.9
	Wrocław	–1.0	1.4
	Gdańsk	–1.0	–3.1
	Białystok	–0.4	–2.9
	Kraków	0.5	0.6
	Poznań	1.0	1.0
Łódź	Warszawa	2.0	1.9
	Katowice	–3.9	–5.2
	Wrocław	–2.7	3.9
	Gdańsk	–2.8	–4.6
	Białystok	–1.7	–4.4
	Kraków	0.1	2.3
	Poznań	1.1	3.2
Katowice	Warszawa	4.6	1.5
	Łódź	0.8	–1.4
	Wrocław	–1.0	4.0
	Gdańsk	–1.1	–6.4
	Białystok	0.2	–6.1
	Kraków	2.3	2.0
	Poznań	3.4	3.1
Wrocław	Warszawa	–2.7	–3.6
	Łódź	–4.9	–5.3
	Katowice	–6.8	–8.5
	Gdańsk	–6.0	–8.2
	Białystok	–5.2	–8.0
	Kraków	–4.0	–3.3
	Poznań	–3.3	–2.7

Following market	Leading market	*Ex post* error 3Q2011	*Ex post* error 4Q2011
Gdańsk	Warszawa	3.2	4.1
	Łódź	0.9	2.4
	Wrocław	–0.1	5.5
	Katowice	–1.0	–0.9
	Białystok	0.6	–0.4
	Kraków	1.8	4.4
	Poznań	2.5	5.0
Białystok	Warszawa	5.2	6.9
	Łódź	2.1	4.6
	Wrocław	0.6	8.8
	Gdańsk	0.5	0.8
	Katowice	–0.5	0.3
	Kraków	3.3	7.3
	Poznań	4.2	8.2
Kraków	Warszawa	0.3	0.1
	Łódź	–1.7	–1.5
	Wrocław	–2.7	1.3
	Gdańsk	–2.7	–4.0
	Białystok	–2.0	–3.9
	Katowice	–3.4	–4.4
	Poznań	–0.3	0.9
Poznań	Warszawa	0.4	0.9
	Łódź	–2.0	–1.0
	Wrocław	–3.2	2.4
	Gdańsk	–3.2	–4.1
	Białystok	–2.4	–3.9
	Kraków	–1.1	1.2
	Katowice	–4.1	–4.5

Source: own calculations based on data from [*Raport*… 2010; 2011].

Table 4. Correlation coefficient values

Market	3Q 2011	4Q2011
Warszawa	–0.19	–0.47
Łódź	–0.08	–0.45
Katowice	–0.59	–0.06
Wrocław	–0.32	–0.06
Gdańsk	**0.39**	**–0.05**
Białystok	–0.16	–0.07
Kraków	–0.67	–0.38
Poznań	**0.93**	**0.73**

Source: own calculations.

relationship. To this end, correlation plots were prepared for the following individual cities for which the forecasts were prepared (Figures 4, 5) and the correlation coefficients were calculated for individual cities (Table 4). Based on those, in the case of forecasts for the 3rd quarter of 2011, Poznań and Gdańsk were identified as cities with a correlation contrary to the one expected. In the case of forecasts for the 4th quarter of 2011, Poznań and Gdańsk again formed this group of cities (very weak negative correlation). Due to this, the correlation coefficients were calculated again, excluding both of these cities. The new correlation coefficient values were higher than before, yet they still did not testify to a strong correlation. The values that were obtained are presented in Table 5. In conclusion, we must stress that the studied correlation was characterized by randomness. While for Łódź, the correlation coefficient for the 3rd quarter of 2011 had a value of –0.08, for the 3rd quarter of 2011 its value was decidedly higher, –0.45. The opposite was true for Katowice, for forecasts for the 3rd quarter of 2011 the correlation coefficient had a rather high value, –0.59, while in the forecasts for the 4th quarter of 2011 its value was significantly lower, –0.06. It is not possible then, in answering the first question posed at the beginning, to show cities where there exists a negative correlation between the measure of similarity with the *ex post* error values of the forecasts constructed.

It was therefore found that even in the case of low (positive and negative) values of the similarity measure, accurate forecasts were obtained (which the calculated

Table 5. Correlation coefficient values

Correlation coefficient	3Q2011	4Q2011
For all markets	–0.23	–0.16
Markets excluding Poznań	–0.29	–0.24
Markets excluding Poznań and Gdańsk	–0.50	–0.34

Source: own calculations.

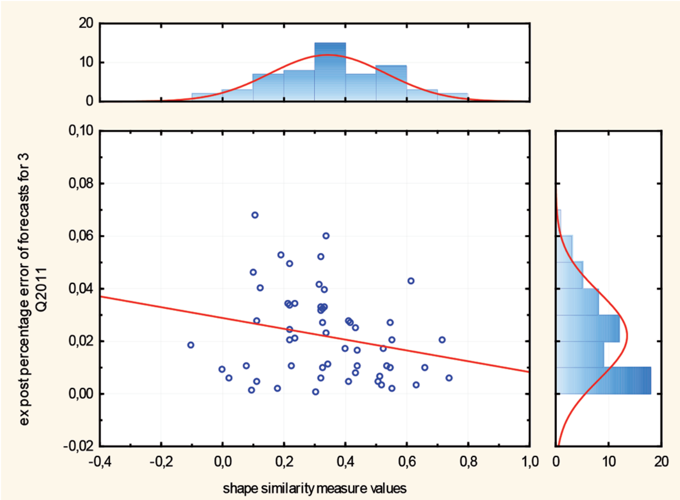

Figure 2. Correlation chart and histograms

Source: own work.

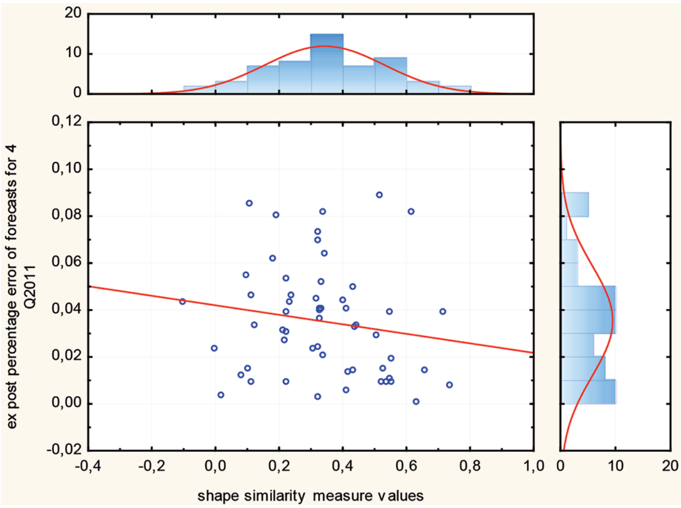

Figure 3. Correlation chart and histograms

Source: own work.

correlation coefficients confirm). This can be explained by the way of forecast construction using the analogue method. Namely, to construct the partial forecast for city X (based on city Y, which is taken to be a leading city) we take the next mean price after the similarity interval in city Y and correct it by the difference of prices between cities X and Y that occurred at the end of the similarity interval. If local

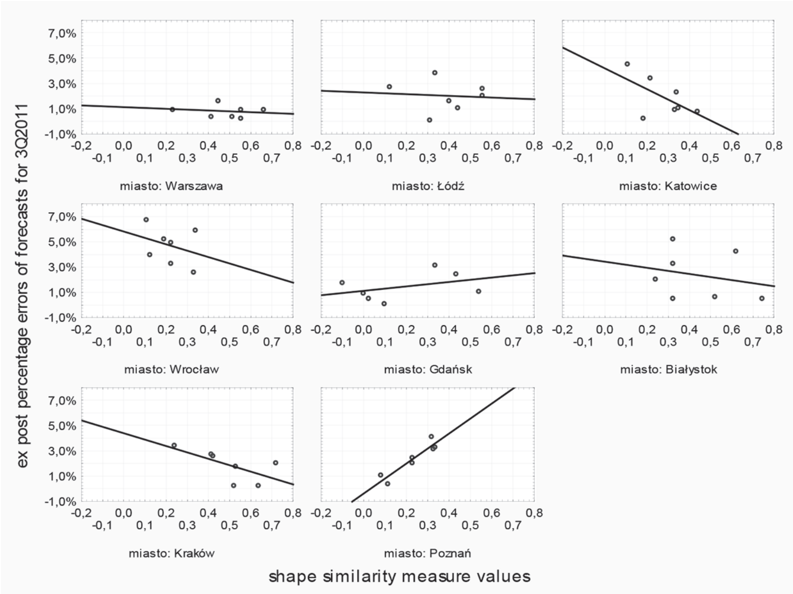

Figure 4. Correlation charts for particular markets
Source: own work.

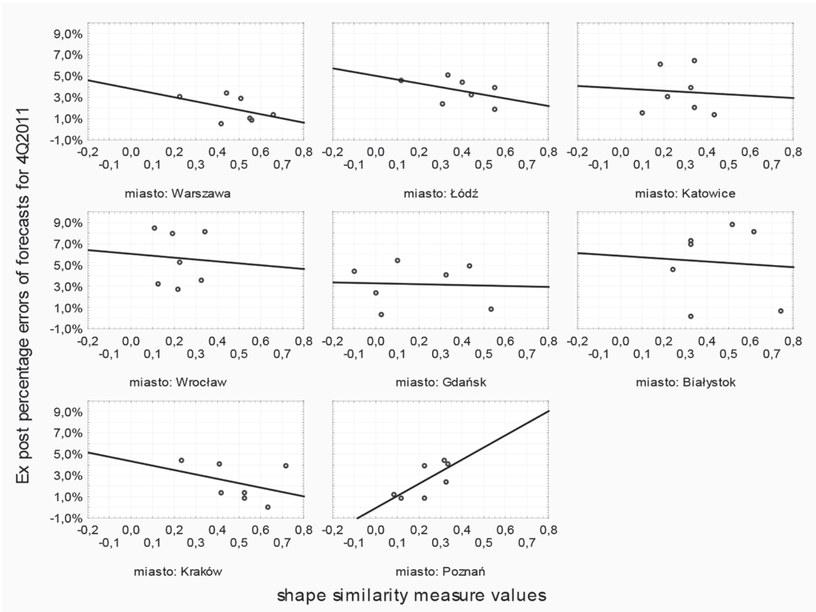

Figure 5. Correlation charts for particular markets

Source: own work.

markets are characterized by stabilization, then the differences between prices in individual markets will remain rather constant, and therefore every city that is taken as a leading city with relation to another, may give an accurate forecast. In this case, the low value of similarity measures which resulted from the formation of the different price changes in the past (for example in the past 18 quarters)[2] was irrelevant.

3. Construction and accuracy of global forecasts

The next question considers the accuracy of global forecasts. In accordance with the procedure shown in [Cieślak, Jasiński 1979] not only partial forecasts, but also global forecasts may be created. Partial forecasts are constructed based on the similarity between the forecasted variable (lagged variable) and the leading variable. By aggregating the partial forecasts we may construct a global forecast. The global forecast is a weighted arithmetic mean of the partial forecasts. The weighting factors are the values of the similarity measure. It may be possible, seemingly, to use the ex post errors of the earlier (expired) forecasts instead of similarity measures as weighting factors.

For each of the cities, forecasts for the 3rd and 4th quarter of 2011 were constructed:

1) global forecasts – type A – based on 7 partial forecasts (based on all the other cities);

2) global forecast – type B – based on partial forecasts of cities that were similar to the city of the forecast (the value of the similarity measure was at least 0.5);

To construct these forecasts, the similarity measures were used as weighing factors. Global forecasts for the 4th quarter of 2011 were also constructed, using the ex post error values of the partial forecast constructed for the 3rd quarter of 2011 as weighing factors (global forecasts – type C). For the constructed forecasts, ex post percentage errors were calculated, whose values are presented in Table 6.

Table 6. Ex post percentage errors of global forecasts (in %)

Markets	Global forecasts type A		Global forecasts type B		Global forecasts type C
	3Q2011	4Q2011	3Q2011	4Q2011	4Q2011
Warszawa	–0.4	–1.0	–0.2	–0.3	–1.0
Katowice	1.3	–0.5	–	–	–3.5
Łódź	–1.1	–0.4	–0.3	2.9	1.9
Wrocław	–4.7	–5.7	–	–	–5.0
Gdańsk	1.1	2.9	–1.0	–0.9	3.7
Białystok	2.2	5.3	1.8	5.9	3.6
Kraków	–1.8	–1.6	–0.9	–1.1	–0.2
Poznań	–2.2	–1.3	–	–	–0.1

Source: own calculations.

[2] The values of the similarity measure used in this article were calculated based on similarity intervals composed of 19 observations in the work [Dittmann 2012a].

In the cases of Katowice, Wrocław and Poznań, there were no cities for which the value of the similarity measure was at least 0.5 (cf. Table 2). Due to this, type B forecasts were not created. The obtained results allow us to form the following conclusions.

First of all, like in previous studies, in the case of every city for which both partial and forecasts type A were constructed, the global forecast had a greater error than the best partial forecast, but a smaller one than the worst partial forecast (Tables 3 and 6). However, since it is not known in advance which partial forecasts will have the smallest error, it is worth to construct global forecasts.

Secondly, different methods of constructing global forecasts allowed us to achieve different forecast accuracies. In most cases, forecasts constructed on the basis of partial forecasts from cities that were similar to the forecast city (the value of the similarity measure being at least 0.5) were characterized by a smaller *ex post* percentage error than forecasts created from all the other local markets.

Thirdly, global forecasts (type C) constructed for the 4th quarter of 2011 with the use of *ex post* errors of partial forecasts proved to be better than forecasts type A and B in half of the cases. Among the studied cities, there were cities on whose basis the partial forecasts formed were characterized by a small *ex post* error in the 3rd quarter of 2011, but by a larger *ex post* error in the 4th quarter of 2011, as well as cities where the opposite was true, i.e. partial forecasts constructed on their basis were characterized by a large *ex post* error in the 3rd quarter of 2011, but a small (acceptable) *ex post* error in the 4th quarter of 2011. In the second case, the global forecasts constructed with the use of weighting factors based on *ex post* errors were worse than others. Only in the case of the leading cities, for which the *ex post* errors for the 3rd quarter of 2011 were similar to those for the 4th quarter of 2011 (i.e. both were high or both were low), the method of forecast construction used here gave better results.

4. Conclusions

The aim of this study was an attempt to answer two questions. The first question was if we can identify specific cities among those studied where a negative correlation of the shape similarity measure with the *ex post* errors of the constructed forecasts existed, and can we also identify cities where such a correlation did not take place. In the article it has been demonstrated that the studied correlation was characterized by randomness. It was not possible to show cities where there existed a negative correlation between the measure of similarity with the *ex post* error values of the forecasts constructed. In the case of Poznań, however, a positive correlation has been identified. It was therefore found that under stability conditions in the latest quarters examined, even in the case of low (positive and negative) values of the similarity measure, accurate forecasts were obtained (which the calculated correlation coefficients confirm). This was explained by the way of forecast construction using an analogue method.

The second question was if replacing shape similarity measures as weighting factors with *ex post* errors of forecasts expired for the construction of global forecasts improves the accuracy of forecasting. To answer this question three types of forecasts were constructed: type A – global forecasts based on 7 partial forecasts (based on all the other cities); type B – global forecast based on partial forecasts of cities that were similar to the city of the forecast; type C – global forecast constructed with the use the *ex post* error values of the expired partial forecasts as weighing factors. It was found that in most cases, forecasts constructed on the basis of partial forecasts from cities that were similar to the forecast city were characterized by a smaller *ex post* percentage error than forecasts created from all the other local markets. Global forecasts (type C) constructed with the use of *ex post* errors of partial forecasts proved to be better than forecasts type A and B in only half of the cases. Only in the case of leading cities, for whom the *ex post* errors for the 3^{rd} quarter of 2011 were similar to those for the 4^{th} quarter of 2011 (i.e. both were high or both were low), did the method of forecast construction used here give better results. It seems this is a significant issue, which requires further study.

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PODOBIEŃSTWA KSZTAŁTOWANIA SIĘ ŚREDNICH CEN TRANSAKCYJNYCH NA RYNKACH MIESZKANIOWYCH W POLSCE A TRAFNOŚĆ KONSTRUOWANYCH PROGNOZ

Streszczenie: W artykule przedstawiono wyniki badań dotyczących prognozowania średnich cen transakcyjnych 1 m^2 na 8 największych rynkach mieszkaniowych w Polsce. Pierwszym problemem badawczym była próba zbadania zależności pomiędzy podobieństwem kształtowania się cen na tych rynkach a wielkością błędów konstruowanych – na postawie tego podobieństwa – prognoz cen. Przeprowadzone badanie wykazało brak ujemnej zależności liniowej. Oznacza to, że większe podobieństwo w kształtowaniu się cen na różnych rynkach nie zawsze umożliwiało konstrukcję prognoz cen obarczonych mniejszymi błędami. Drugim problemem badawczym była próba budowy prognoz globalnych cen średnich... Uzyskane rezultaty badania wykazały, że zaproponowany sposób budowy prognoz globalnych był, w porównaniu z tradycyjnym, w przypadku niektórych rynków lepszy, natomiast w innych – gorszy.

Słowa kluczowe: podobieństwo kształtu, prognozowanie, rynek mieszkaniowy.