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INTEGRATION AND COINTEGRATION OF APARTMENT PRICES ON THE PRIMARY AND SECONDARY MARKET IN SZCZECIN IN THE YEARS 2006-2022

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ABSTRACT

The objective of the paper is to verify hypotheses regarding integration and cointegration (relation) of mean apartment prices on the primary and secondary market in Szczecin. Both transaction prices as well as offer prices of apartments were investigated. The analysis period encompasses the years of 2006 – 2022 (quarterly data). An ADF test was employed to examine the integration of time series, taking into consideration a deterministic component in the form of a quadratic function. Only the time series of mean offer prices and transaction prices on the primary market proved to be integrated in the first degree. The time series of mean offer prices and transaction prices on the secondary market were not integrated, they occurred to be trend stationary series. A two-step Engle-Granger test was employed to analyze the cointegration of time series, which confirmed the cointegration of mean offer prices and transaction prices on the primary market. The relations between individual price types were examined with the use of a procedure which entailed analyzing (with an ADF test) difference stationarity between prices. From the empirical studies it arises that, in Szczecin, transaction and offer prices on the primary market follow one another. On the secondary market, offer and transaction prices are trend stationary and they converge. On the other hand, prices on the primary market diverge from prices on the secondary market (the primary market diverges from the secondary market). This concerns both offer prices as well as transaction prices.

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1. Introduction

In recent years, apartment prices have been rising dramatically, both on the primary and the secondary markets. Price dynamics have been especially high on the primary market. This is of particular significance in the socio-economic aspect. Rapidly growing apartment prices limit the possibility of satisfying the population's housing needs. The situation is further complicated by very high inflation and interest rates (high cost of credit), or by the rapidly increasing costs of building investments. All of the above factors cause the understanding of the mechanisms of apartment prices on the local markets to take on special importance.

In the article, an attempt was made at the econometric identification of the time series structure of mean apartment prices on the primary and secondary market in Szczecin. Both offer and transaction prices are analyzed. The analysis period encompasses the years of 2006 – 2022 (quarterly data). Firstly, deterministic components of time series were defined. Then, with the use of an ADF test, the hypotheses of time series integration were verified. If a series is integrated, then it demonstrates a stochastic trend. The study additionally aimed to determine whether individual types of prices are related to one another (cointegrated).

In the study, an attempt was made at finding answers to the following questions:

1) Are the time series of mean offer and

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transaction prices on the primary and secondary market integrated (do they demonstrate stochastic trends)?
2) Are the offer and transaction prices on the primary market related?
3) Are the offer and transaction prices on the secondary market related?
4) Are the offer prices on the primary and secondary market related?
5) Are the transaction prices on the primary and secondary market related?

2. Literature review

The literature concerning the general study of the integration and cointegration of variables is very extensive. Descriptions of methodological issues related to testing integration and cointegration of variables can be found as early as in classic works of e.g. Charemza & Deadman (1997), Dickey and Fuller (1979), Engle and Granger (1987), Johansen (1991), Maddalaand Kim (1998), or Maddala & Lahiri (2009).

The literature on the relationships of apartment prices on the primary and secondary market, with a differentiation of offer and transaction prices, is not overly substantial. Cointegration between offer prices and transactional prices on both primary and secondary real estate markets (17Polish biggest cities) were analyzed in Drachal (2015). Generally, it was found that primary and secondary markets are not cointegrated.

There are quite many studies concerning the dynamics of apartment prices in other countries (e.g. Oikarinen, et al., 2018; Jud & Winkler, 2002; Englund & Ioannides, 1997; Hamid et al., 2022). In the paper of (Oikarinen, et al., 2018) data for 70 metropolitan areas of the United States were used in order to examine the spatial heterogeneity of house price dynamics. Models of panel econometrics were employed, which take into account spatial heterogeneity, spatial relations and variable cointegration. The article by (Jud & Winkler, 2002) features a wide-ranging study of apartment price dynamics in 130 metropolitan areas in the United States. The analyses demonstrate that real appreciation of apartment prices is significantly affected by increases in population size, income, building costs and interest rates. It was further found that appreciation indexes of house prices differ regionally on account of the impact of location. Apartment prices are additionally affected by limitations in land availability. The dynamics of apartment prices in 15 OECD countries were compared in the paper of (Englund & Ioannides, 1997). The results of the study demonstrate a high degree of similarity of the time series of apartment prices in individual countries. Moreover, it was shown that the dynamics of apartment prices feature a significant degree of autocorrelation. In certain studies (Hamid et al., 2022) changes on the housing market are analyzed in terms of the probability of speculative bubbles occurring.

The National Bank of Poland has been conducting systematic studies of apartment prices dynamics on the primary and secondary market, broken into offer and transaction prices, cf. (Łaszek et al., 2022).The relations between apartment prices on the primary and secondary market for selected cities in Poland are analyzed in the paper by Kokot (2022). Research results demonstrated that, in the majority of the analyzed cities, apartment prices on the primary market are higher than on the secondary market, although there are situations in which the reverse is true. It was noted that the analyzed relations on the primary and secondary market are not permanent and feature a high degree of variability, both in time and in space. The relations between apartment prices on the primary and secondary market are also analyzed in the article by Leszczyński & Olszewski(2017). That study encompasses 17 of the largest cities in Poland in the years from 2002 to 2015. The results suggest that apartment prices depend on such economic factors as income, unemployment and real interest rates, with prices on the secondary market reacting more strongly to these factors (particularly to interest rates). It is observed that, on account of different specificity, the primary and secondary markets ought to be analyzed separately. The dependencies between different segments of primary and secondary markets in Warsaw were presented in (Brzezicka et al., 2019).

The paper by Leszczyński & Olszewski(2013) contains a panel analysis of the local conditions of apartment prices on the primary and secondary markets in 17 cities in Poland. It was determined that apartment prices depend on fundamental factors (income, unemployment, loan availability). Additionally, a strong inertia of apartment prices was noted, which may be indicative of "herd" behavior. The results of the analyses demonstrate that the primary market exerts a stronger influence on the secondary market (than the secondary market does on the primary one).

The relations between different types of apartment prices are additionally examined taking into

consideration price convergence (Matysiak & Olszewski, 2019). The occurrence of price convergence means that price differences are decreasing. The conclusions for the largest cities in Poland do not indicate price convergence, although groups of cities can be identified in which price convergence does occur. However, such groups are geographically non-homogeneous. House price convergence is also analyzed in Tomal (2019) and Tomal (2020). The questions related to the impact of economic cycles on apartment prices are analyzed in Główka (2018) and Tomal (2022).

3. Data and Methods

3.1. Sample information

The study involves the time series of mean offer and transaction prices on the primary and secondary market in Szczecin in the period from III 2006 to III 2022 (quarterly data). The data come from the website: www.nbp.pl. The following designations were adopted for variables:

y_{1t} – mean offer prices on the primary market,
y_{2t} – mean transaction prices on the primary market,
x_{1t}– mean offer prices on the secondary market,
x_{2t}– mean transaction prices on the secondary market.

The main objective of the study involves identifying relations between variables, which is why the prices adopted in the study were nominal prices. Adjusting each of the analyzed variables by the same rate of inflation would not change the relation occurring between such variables. The dynamics of the time series have been presented in the charts below.

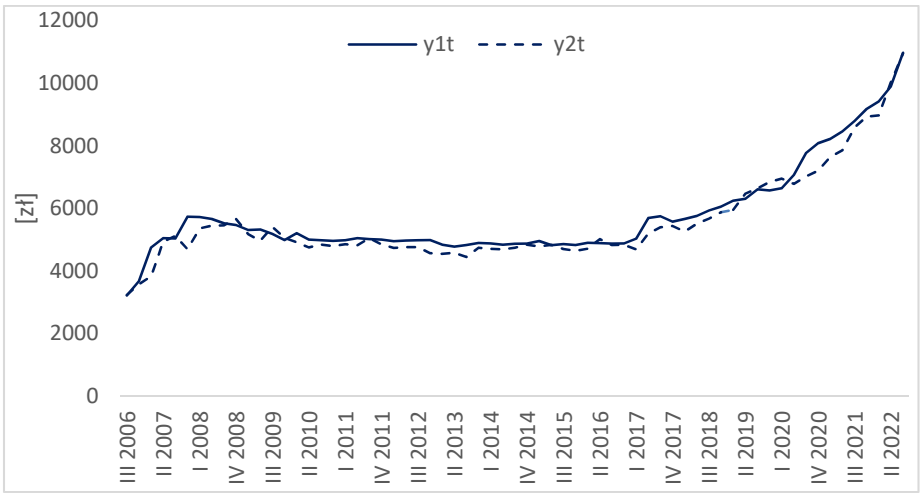


Fig. 1. Dynamics of mean offer prices (y_{1t}) and transaction prices (y_{2t}) on the primary market in Szczecin.*Source*: own elaboration on the basis of www.nbp.pl.

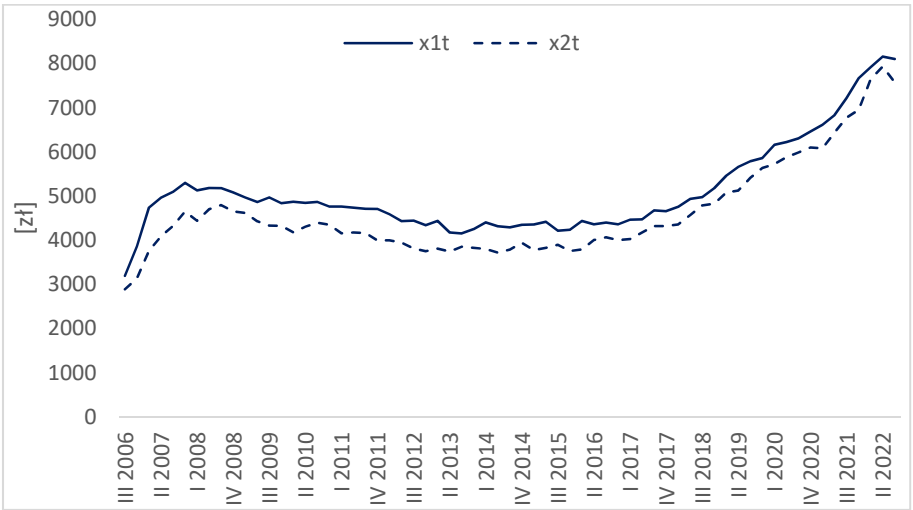


Fig. 2. Dynamics of mean offer prices (x_{1t}) and transaction prices (x_{2t}) on the secondary market in Szczecin. *Source*: own elaboration on the basis of www.nbp.pl.

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By analyzing the dynamics of apartment prices in Szczecin, it is possible to identify the phases ofhousing market development cycles. Average prices of flats increased until 2008, after which they stabilized (primary market) or slightly decreased (secondary market). From the beginning of 2017, apartment prices began to increase dynamically, which lasted until the end of the analyzed period.

3.2. Methods

When examining the relations between non-stationary time series we cannot use such measures as the Pearson correlation coefficient, or multiple regression directly. A non-stationary time series features changing expected value and/or variance. Measures like the Pearson correlation coefficient may indicate strong relations, which may result from variable trends (and not from relations between variables). Such a phenomenon is known as spurious correlation (regression). That is why, in the first step, variables need to be reduced to stationarity. For the time series with a deterministic trend (trend stationary series), the trend is eliminated by introducing a time variable into the equation, following which the residuals of this type of regression are analyzed. For the series demonstrating stochastic trends (difference stationary series) subsequent differences are calculated until the moment when stationarity occurs.

A time series may consist of a deterministic trend, a stochastic trend, deterministic seasonality, stochastic seasonality and random disturbances. In the case of long time series, cyclical fluctuations may also appear, which may sometimes be taken into consideration with a deterministic component.

The graphic analysis of the series presented above does not indicate the occurrence of any significant seasonal fluctuations. A preliminary analysis demonstrated that seasonal fluctuations are not statistically significant. In the estimated models seasonal dummy variables were taken into consideration, but were not found to be statistically significant. Stochastic seasonality was also not considered. A preliminary graphic analysis shows the occurrence of a deterministic component in the form of a third degree polynomial. The degree of integration of the analyzed time series was defined with the use of the ADF test.

The following regression equations were estimated

$$\Delta y_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \varphi y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \epsilon_i \quad (1)$$

where:
$\Delta y_t = y_t - y_{t-1}$ – variable first differences,
t – time variable,
k – number of lags,
ϵ_t – white noise.

An autoregressive term of $\sum_{i=1}^{k} \gamma_i \Delta y_{t-i}$ is taken into account in order to eliminate autocorrelation. Number of lags (k) was determined on the basis of the AIC information criterion. The assumed maximum number of lags was equal to 10. This value arises from the length of a time series. Then, such a k was chosen for the model which (1) featured the lowest AIC value. A test variant with a square trend was adopted. The time series (time series levels) are shaped in line with a third degree polynomial, while model (1) is estimated for variable first differences, that is why a deterministic component in model (1) contains a square trend (for first differences, the polynomial degree is lower by one than it is for the levels of the same variable).

In the ADF test, the hypotheses assume the following form:

H_0: $\varphi = 0$ – series is integrated in the first degree; type $I(1)$ series

H_1: $\varphi < 0$ – the series is trend stationary; type $I(0)$ series

In the article, the level of significance adopted for hypotheses verification is $\alpha = 0.2$. It is greater than the typically adopted values of 0.01 or 0.05. The adoption of higher significance levels in the ADF test results from the rather low power of such a tests (Maddala & Lahiri, 2009).

If the series are integrated, their cointegration might be tested. The concept of cointegration was proposed by Engle and Granger in the 1980's. Cointegration proves the existence of a long term relationship between variables. If cointegration does not occur, the processes diverge in time (the difference between them is not constant).

Let us assume that we analyze two integrated processes of random walk, which are independent of one another: $y_{1t} = y_{1,t-1} + v_t$; $y_{2t} = y_{2,t-1} + n_t$, where v_t, n_t are random components (white noise). The regression equation of $y_{1t} = \alpha + \beta y_{2t} + u_t$ for these processes can feature a high R^2 value, or a significant t-Student statistics value. However, the regression is spurious, since the processes are, in fact, independent from one another. Apart from the cointegration tests (Engle – Granger test, Johansen test), Durbin Watson d statistics may be helpful here. If $d < R^2$, then we are most likely dealing with spurious regression.

Let us assume that variable y_{1t} is integrated in d degree, i.e. $y_{1t} \sim I(d)$, while variable y_{2t} is integrated in

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b degree, i.e. $y_{2t}\sim I(b)$, where $d \geq b > 0$. Variables $y_{1t}$and y_{2t} are cointegrated, which is marked as $CI(d,b)$, if there exists such a combination of variables which forms a series integrated in $(d-b)$ degree, i.e. $y_{1t} - \alpha - \beta y_{2t}\sim I(d-b)$. For instance, if variables are integrated in the first degree, i.e. $y_{1t}\sim I(1)$and$y_{2t}\sim I(1)$, then the variables are cointegrated, which is written as $CI(1,1)$, if a linear combination of such variables forms a stationary series, i.e. $y_{1t} - \alpha - \beta y_{2t}\sim I(0)$. If variables are cointegrated, the following regression $y_{1t} = \alpha + \beta y_{2t} + u_t$ is justified (in the long term variables "follow one another").

The procedure proposed by Engle and Granger can be employed in examining cointegration, in which an ADF test is applied to the residuals of the following regression function: $y_{1t} = \alpha + \beta y_{2t} + u_t$. At an earlier stage, a hypothesis of an identical degree of integration of the analyzed time series must be verified.

Regression equation in the Engle – Granger cointegration test is as follows

$$\Delta u_t = \varphi u_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta u_{t-i} + \varepsilon_t \quad (2)$$

The hypotheses take the following form

$H_0: \varphi = 0$ (presence of unit root, lack of cointegration)

$H_1: \varphi < 0$ (stationary series, cointegration).

Test statistics is the value of t-Student statistics $t(\hat{\varphi})$ for parameter φ in equation (2). If there are no grounds for rejecting H_0, then cointegration does not occur (the residuals are integrated in the first degree). If H_0 is to be rejected, variables are cointegrated (the residuals are stationary). The power of Engle – Granger test depends on the quality of the cointegrating equation: $y_{1t} = \alpha + \beta y_{2t} + u_t$. The better the properties of that equation, the greater the power of the test.

3.3. Empirical results

The results of the ADF test for the levels of variables and their differences are presented in the table 1. If there is no basis for the rejection of the hypothesis that variable $y_{1t}$is $I(1)$, then the hypothesis that Δy_{1t} is $I(1)$ must be verified. If the latter hypothesis needs to be rejected, then variable y_{1t} is $I(1)$ (and not $I(2)$).

The time series of offer and transaction prices on the primary market are integrated, thus their cointegration can be examined. If cointegration does not occur, these series are not related with one another (they do not follow one another over the long term). The study of relations for integrated variables that are not cointegrated may lead to spurious regression.

Table 1

Result of ADF test for examined variables

Variables	$\hat{\varphi}$	$t(\hat{\varphi})$	p_{value}	autocorrelation order (k)
y_{1t}	0.131	1.258	1	10
Δy_{1t}	-2.658	-3.412	0.137	10
y_{2t}	-0.217	-3.068	0.264	2
Δy_{2t}	-1.467	-6.973	<0.001	1
x_{1t}	-0.238	-7.991	<0.001	0
x_{2t}	-0.500	-4.652	0.004	6

Source: own study.

If p – value is greater than $\alpha = 0.2$, then there are no grounds for rejecting H_0 regarding the occurrence of a unit root. On the basis of the above table, it can be concluded that there are no grounds for rejecting the hypothesis that $y_{1t}\sim I(1)$ (the series is integrated in the first degree). In order to verify whether y_{1t} is not integrated in the second degree, the hypothesis that $\Delta y_{1t}\sim I(1)$ was verified, which would mean that $y_{1t}\sim I(2)$. This hypothesis ought to be rejected, and thereby it can be assumed that $y_{1t}\sim I(1)$. In the case of y_{2t} the conclusions are analogical, i.e. $y_{2t}\sim I(1)$. Therefore, it can be concluded that the time series of mean offer and transaction prices on the primary market demonstrate stochastic trends (apart from a deterministic component).

In turn, the time series of mean offer and transaction prices on the secondary market are trend stationary series. For variables x_{1t} and x_{2t}, H_0, according to which the series are $I(1)$, needs to be rejected.

Variables y_{1t} and y_{2t} are integrated, hence their cointegration might be verified. For mean offer and transaction prices on the primary market the cointegration equation assumes the following form

$$\hat{y}_{1t} = 217.217 + 0.997 y_{2t}, R^2 = 0.969, d = 1.401, t(\hat{\beta}) = 44.25 \quad (3)$$

The coefficient next to variable y_{2t} in Equation (3) is virtually equal to one. Thus is can be concluded that there was a constant difference between offer and transaction prices on the primary market equal to PLN 217.22. This is an estimate of the constant term in model (3). The model is very well adjusted to the empirical values. Also, the following inequality occurs $d > R^2$, which may additionally confirm the cointegration of variables. Parameter β is statistically significant $\left(t(\hat{\beta}) = 44.25,\ p_{value} < 0.001\right)$.

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The results of a test for the presence of a unit root in residuals of model (3) are as follows: $\hat{\varphi} = -1.159, t(\hat{\varphi}) = -5.127, p_{value} < 0.001$. These are the estimates of the equation (2). H_0 regarding the lack of cointegration needs to be rejected, the variables are cointegrated (residuals of the cointegrating equation are stationary).

Recapitulating, the prices on the primary market are integrated and cointegrated. In turn, the prices of the secondary market are trend stationary.

It can be concluded that the relations between individual types of prices basically depend on a deterministic component (a third degree polynomial of a time variable). Theoretical values of deterministic components are presented in the Fig. 3.

The graphic analysis indicates that offer and transaction prices on the primary market are strongly related and they are close to one another. Prices on the secondary market also follow one another. Additionally, it can be noticed that, in the recent years, the difference between offer and transaction prices on the secondary market has been decreasing.

The relations between individual types of prices may be further examined by analyzing the differences between them. Prices are measured in the same units (PLN), thus the nature of those variables is the same. Therefore, an examination of difference stationarity between prices may lead to conclusions of their relation (or lack of such a relation). If, for instance, the differences between offer and transaction prices on a given market are stationary, then it can be assumed that they are cointegrated (they follow one another). The differences between individual types of prices have been presented in the Fig. 4-5.

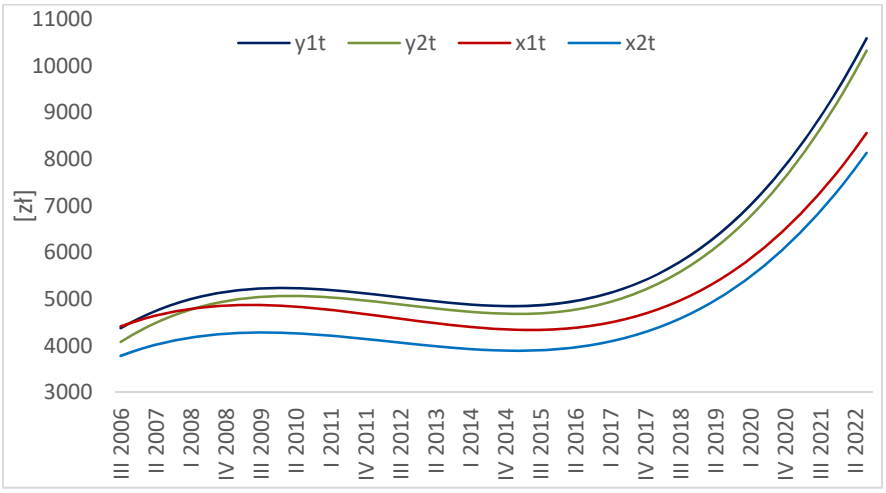


Fig. 3. Deterministic components of mean offer and transaction prices on the primary and secondary market in Szczecin. *Source*: own elaboration.

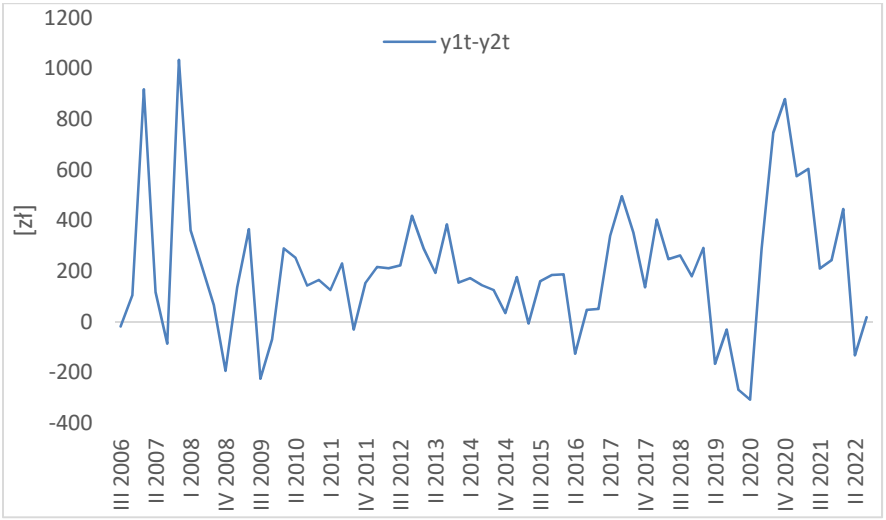


Fig. 4. Differences between offer and transaction prices on the primary market in Szczecin. *Source*: own elaboration on the basis of www.nbp.pl.

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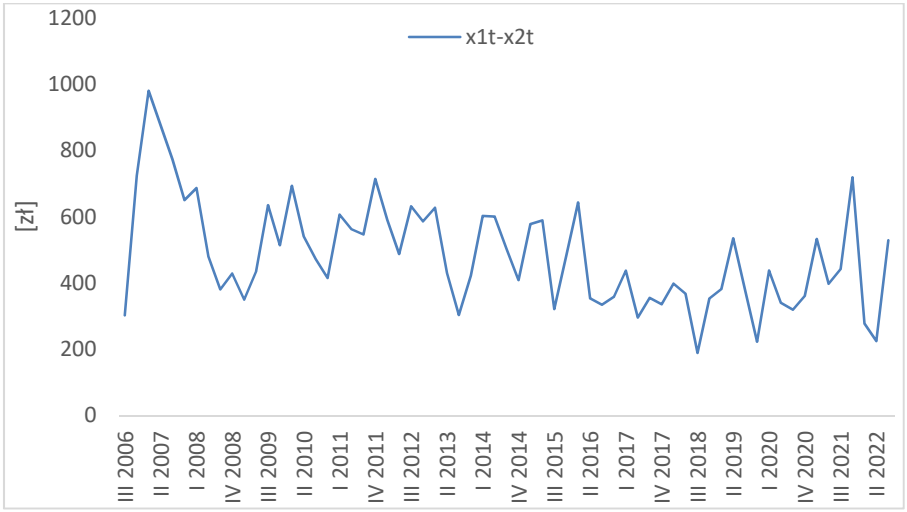


Fig. 5. Differences between offer and transaction prices on the secondary market in Szczecin. *Source*: own elaboration on the basis of www.nbp.pl.

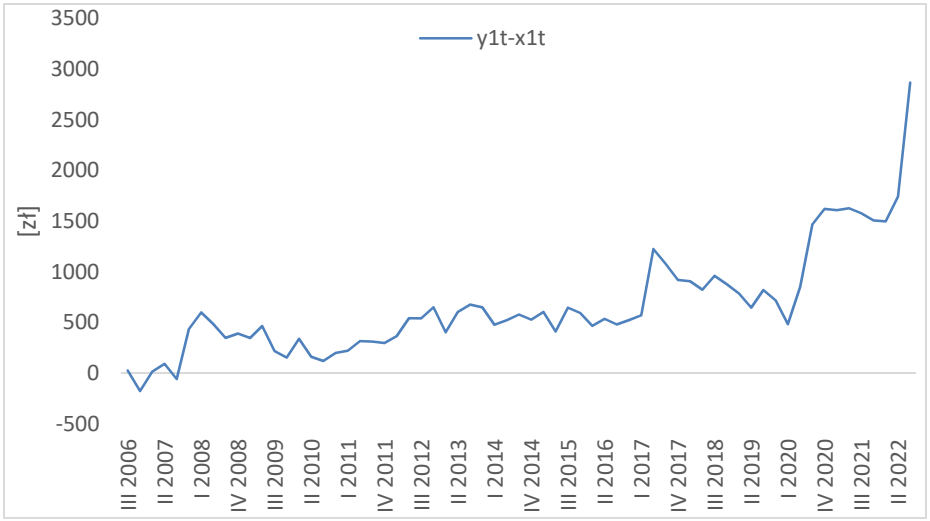


Fig. 6. Differences between offer prices on the primary and secondary markets in Szczecin. *Source*: own elaboration on the basis of www.nbp.pl.

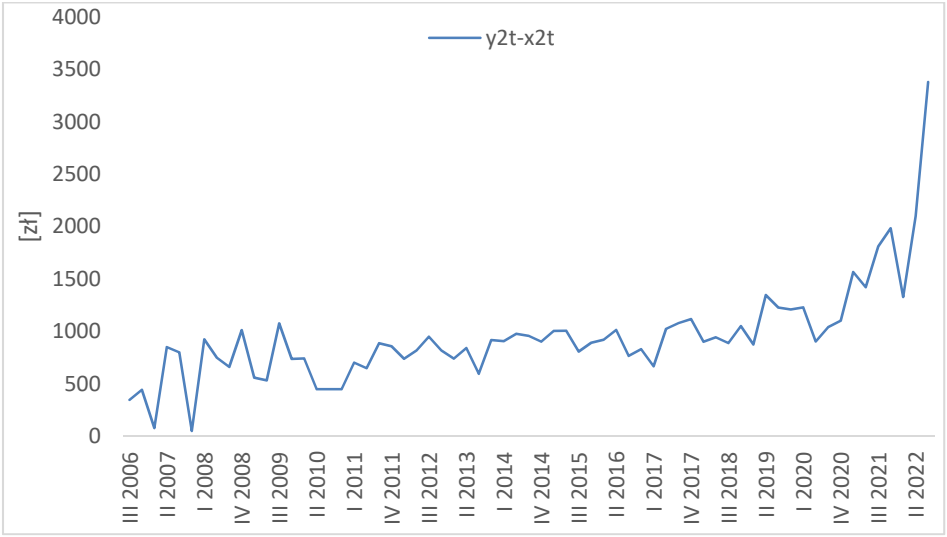


Fig. 7. Differences between transaction prices on the primary and secondary markets in Szczecin. *Source*: own elaboration on the basis of www.nbp.pl.

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Figs. 6 – 7 show a clear increase in the differences between the respective prices on the primary and secondary markets. These differences may signal the existence of a speculative bubble in these markets.

An ADF test was used to verify the hypothesis of difference stationarity between the applied prices. The test variant with a constant term was adopted. Additionally, the significance of a delay for $k \leq 10$ was tested, assuming AIC as the criterion of model selection. The results of the test are presented in the Table below.

Table 2

Results of ADF test for examined variables

Variables	$\hat{\varphi}$	$t(\hat{\varphi})$	p_{value}	auto-correlation order (k)
$y_{1t} - y_{2t}$	-1.193	-5.205	<0.001	6
$x_{1t} - x_{2t}$	-0.374	-2.964	0.038	2
$y_{1t} - x_{1t}$	0.255	2.169	1	10
$y_{2t} - x_{2t}$	0.418	2.613	1	5

Source: own study.

At the significance level of $\alpha = 0.2$, the hypothesis of non-stationarity (regarding the occurrence of a unit root) needs to be rejected in the two first cases. It can thus be stated that the differences between offer and transaction prices on the primary market were stationary. Analogous conclusions refer to the secondary market. On this market, the differences between offer and transaction prices were also stationary. This means that transaction and offer prices follow one another (within the scope of the same market). On the other hand, the differences between offer prices on the primary and secondary market were non-stationary, and differences between transaction prices on the primary and secondary market were non-stationary as well. Thus, it can be concluded that the prices on the primary market diverge from analogous prices on the secondary market. This trend has become particularly evident in the recent years.

4. Discussion and conclusions

The primary apartment market has a different specificity than the secondary one. The secondary market features far higher diversification (heterogeneity). On the primary market, new apartments are offered, which are often quite similar to one another (they feature similar constructional or architectural solutions). On the secondary market, apartments offered for sale are of various age and differ in terms of their building technology, architecture, degree of use, etc.

On the basis of the conducted research, it can be affirmed that the time series of mean apartment prices on the primary market have different properties than analogous series on the secondary market. The same deterministic component in the form of a third degree polynomial constitutes a common trait of all the examined time series. This component probably results from the length of the time series (initial observations regard the year 2006). What is more, the prices were not adjusted for inflation, which has significantly sped up the apartment price increase in the recent years, especially on the primary market. For the record, the objective of the study was to examine the relations between individual types of prices. Adjustment for variables by the same inflation index does not affect the relation between them, which is why nominal prices might be employed in the analysis.

The time series of mean apartment prices on the primary market were integrated in the first degree, i.e. they demonstrated – apart from the deterministic component – stochastic trends as well. Offer prices and transaction prices were also cointegrated, that is why it can be concluded that they follow one another. Moreover, the differences between offer and transaction prices on the primary market were slight.

On the other hand, the time series of prices on the secondary market were trend stationary, thus they demonstrated properties other than analogous time series on the primary market. Furthermore, a decreasing difference between offer and transaction prices on the secondary market can be observed.

Recapitulating, answering the research questions posed at the beginning, it can be said that offer prices are related with transaction prices, both on the primary market as well as on the secondary one. However, the primary market diverges from the secondary market. Offer prices on the primary and the secondary market diverge, as do transaction prices (on the primary and the secondary market). These results may be indicative of the economic situation on the Szczecin apartment market "overheating" in recent years, particularly on the primary market.

Strict relations between offer and transaction prices both on primary and secondary markets are not a surprise. However, growing differences between respective prices between the primary and secondary market might support the hypothesis about the occurrence of a price "bubble".

The phase of the business cycle may be a factor influencing the relationship between offer and

transaction prices, both on the primary and secondary markets. In each phase of the cycle, these relationships may be different. Such relationships will be the subject of future real estate price research.

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