THE LONG TERM MODELING
OF RESIDENTIAL PROPERTY PRICES IN POLAND

Rafał Zbyrowski (ORCID: 0000-0001-8499-8899)
Faculty of Management, Warsaw University, Poland
e-mail: rzbyrowski@wz.uw.edu.pl

Abstract: The main purpose of this article is to describe a dependence between prices of flats and index of creditworthiness in Poland. In the empirical part of this paper the author tests mentioned relations according to Engle-Granger's procedure. Moreover the long time relation had been verified by Johansen's procedure and a VAR model. This case leads to the examination and estimation cointegration with testing lags between very important variables on real estate market in Poland. The database used in the research contains monthly observations from the middle of 2010 to the beginning of 2014.

Keywords: Econometric modeling, VAR, VEC, real estate, residential real estate.

INTRODUCTION

The activation of government programs related to support housing construction in Poland had been carried out since the nineties. Old tax incentives have been replaced by much less effective programs "Family on its own" (Rodzina na swoim) and then "Apartment for the young" (Mieszkanie dla młodych). Over the last 25 years the real estate market in Poland passed tumultuous changes. Systematically the market had become free of large-scale government campaigns. The older government campaigns had been aimed at the activation of the housing sector (in favor of an increase the role of macroeconomic variables, among which a special role is played by factors affecting the creditworthiness of households). The creditworthiness is dependent on many determinants such as incomes, credit periods, the currency of the loan, interest rates or the number of members constituting the household. Of course, the most important is the borrower's income. Average wages in 2005-2013 had increased by 53,5%, while inflation during this

period amounted to 45,45%. It shows that real incomes had increased by 8%. Thus, in theoretical terms creditworthiness should had been increased. Unfortunately, it did not happen because in the period 12.2007-12.2013 the creditworthiness decreased by 15% (Figure 1). The real wage growth has not caused an increase of the creditworthiness for apartment buyers. An important factor which determine the creditworthiness is also the interest rate. It depends on the WIBOR 3M for credit in PLN (in rare cases the 3M EURIBOR for the euro). This indicator is a derivative with respect to the rate of inflation. In the years 2005-2012 the 3M WIBOR amounted to approx. 5%. The maximum of 6.41% had been noted in 2008, while the world crisis had been reaching Poland. In 2013 the 3M WIBOR fell by 76% compared to 2012. At the present time, its value at the level of 1.73% is almost the lowest in history. According to Home Broker (Figure 1) the index of creditworthiness for a 3-person family with a net income of 5000 zł increased in the period from 12.2012 to 04.2014 by 10.6%. Thus, the average family could receive an average of 387 000 zł credit in April 2014 year instead of 350 000 zł in December 2012. The increase in creditworthiness increases the demand. Consequently, it causes an increase in real estate prices. This economic dependence is reflected in graphs of the time series (Figure 1) in the context of which raise the following questions:

Is there a long-term relationship between the level of prices in the housing market and the credit worthiness in Poland? What is the real strength of this relationship?

On these questions the author tries to answer on the basis of analysis carried out in cointegration Engle-Granger's and Johansen's procedures.

THE LEVEL OF PROPERTY PRICES AND THE AVERAGE CREDITWORTHINESS

The years from 2008 to 2012 are considered to be the period of crisis in the polish economy. The following chart 1 shows quickly declining creditworthiness of consumers and how this affected the price of real estate in Poland. As we can see a lot of fluctuations in the market were associated with activities of banks and government institutions.

Figure 1. The level of property prices and the average creditworthiness
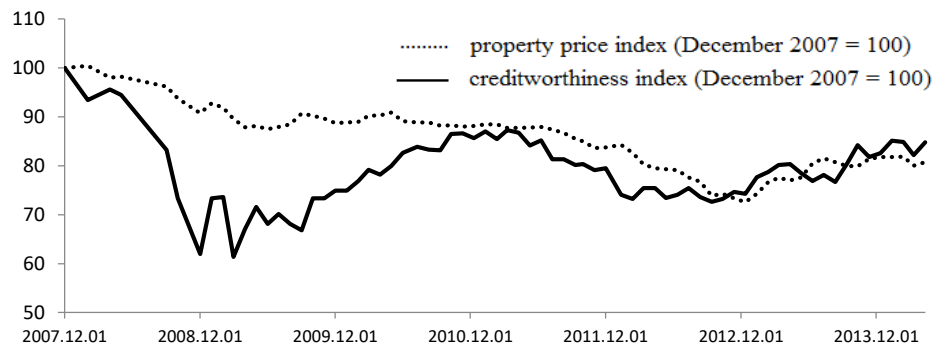
Source: portal www.egospodarka.pl

     Observed in the years 2008 - 2012 the fluctuation in housing prices has progressed at different stages with varying dynamics. In the period from January 2008 to mid-2009, housing prices fell quicker. The reason for this was limited crediting by banks caused by high credit spreads, decline in the creditworthiness of consumers and increase the number of negative credit decisions. Above all the most important had been the limitation of foreign currency credits - especially in CHF. In subsequent months, the credit market gradually began to affect interest rate cuts, which reduced the cost of financing. Important was also raising the price limits in the "Family on its own" government program. According to higher price limits even relatively expensive housing could be subsidizing. In 2010 and 2011 there has been a stabilization of housing prices despite the rapidly increasing supply in the primary market. The higher supply was caused by the liberalization of the credit policy of commercial banks. At the beginning of 2011, there were increases in interest rates. Moreover in 2011 government institution (KNF) tightened requirements on the availability of credit. According to regulations of the financial supervision (KNF) the amount of credit installments could not exceed 50% of net income for citizens earning below the national average and 65% of income for the others. This resulted in a gradual decline in the purchasing power of housing buyers. The limitation for buyers was also a decrease the availability of the government program "Rodzina na swoim" from August 2011. From this moment a much lower price limits had eligibled for housing subsidies in most cities. The program caused stimulating the competition between the supply side of the market. At the beginning of 2012 KNF entered into force the revised recommendation "S", which limited the demand for residential properties a few months later. New regulations had hindered the access to mortgage loans in foreign currencies, and also had changed the method of calculating creditworthiness. From that moment, regardless of the mortgage duration, banks evaluated the ability of credit as if it was made on the 25 years. Enacted legislation caused a decrease in the index of housing prices. It can be said that the situation in the credit market had a very

significant impact on the dynamics of real estate prices. During the five-year depreciation of housing values we can see moments when it accelerate with decreasing availability of the mortgage financing. Since the end of 2012 to today, the ability to credit and property prices are rising as shown in the Figure 2.

THE RESEARCH METHOD

Using the Engle-Granger's procedure, we can define and estimate cointegration on the basis of economic theory [Charemza 1997]. This procedure shows the dependence in a form of a regression equation:

$$\ln Y_t = \beta \cdot \ln X_t + c + \xi_t \tag{1}$$

The regression expresses a long-term equilibrium relation between the variables X and Y [Enders, 2003]. In the empirical part of this article we can find an example of an application of Engle-Granger's procedure for cointegration modeling. This procedure comprises the following steps:

1. Definition for the variables (as dependent and independent variable on the basis of theory).
2. The examination of a stationary for variables X_t and Y_t in the equation: $\ln Y_t = \beta \cdot \ln X_t + c + \xi_t$ (both variables are integrated at the first difference in the most common case).
3. The estimation of the regression $\ln Y_t = \beta \cdot \ln X_t + c + \xi_t$ by LSM.

4. Testing stationary for residuals previously created from the regression. Stationary residuals indicates the existence of the cointegration vector, which describes a long-term relationship between variables X_t and Y_t. The correct relationship $\ln Y_t = \beta \cdot \ln X_t + c + \xi_t$ creates the opportunity to build a short-term error correction model ECM: $\Delta \ln Y_t = \alpha \cdot \Delta \ln X_t - \gamma \cdot \xi_{t-1} + c_1$

Fundamentals of methodological procedures for the Engle-Granger's approach limit the research to identifying at most one cointegration vector (Gajda 2004). The specified cointegration vector may be only one of many such vectors.

THE RELATIONSHIP BETWEEN REAL ESTATE PRICES
AND THE CREDITWORTHINESS

Time series shown in the Figure 2 have a monthly frequency since 2009. Property price indexes (ICN_t[1], December 2007 =100) and creditworthiness (IZK_t[2],

---

[1] ICN_t – published monthly by the Home Broker and Open Finance index of housing prices formed on the basis of transactions in 16 cities (Bialystok, Zielona Góra, Bielsko-Biala, Torun, Bydgoszcz, Krakow, Lublin, Gdansk, Gdynia, Olsztyn, Katowice, Lodz, Poznań, Szczecin, Wrocław and Warsaw). The index is calculated according to the formula: $Index = C_1 \cdot \left(\frac{l_1}{St}\right) + C_2 \cdot \left(\frac{l_2}{St}\right) + C_3 \cdot \left(\frac{l_3}{St}\right) + C_4 \cdot \left(\frac{l_4}{St}\right) + \dots + C_{16} \cdot \left(\frac{l_{16}}{St}\right)$

December 2007 =100) have been prepared by Lion'sBank (based on data from banks, mortgage lenders and the companies of Home Broker and Open Finance). Index values for the initial sample size (especially the last months of 2008) are illustrative purpose only because of the irregular frequency.

Figure 2. Indexes of the real estate prices and the creditworthiness in the years 2008-2014
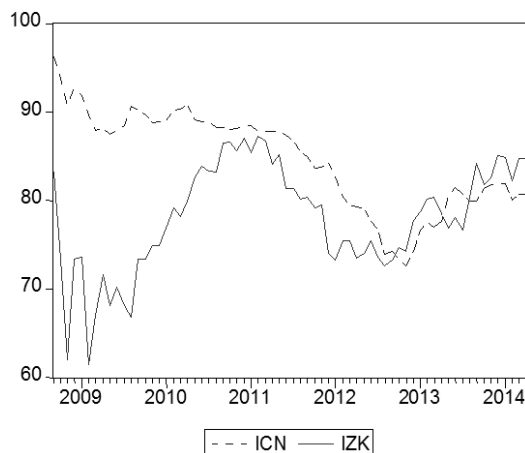
Source: own preparation based on www.egospodarka.pl

The Figure 2 during the period 2008.09 - 2014.04 reveals considerable divergence of indexes during the global crisis. We can see a common trajectory of the time series from 2010.09 to 2014.04. Fluctuations of balance in the years 2008 - 2010 were so strong that they caused a complete reversal depending based on economic theory between ICN_t and IZK_t. Since the last months of 2010 up to now we can observe the presence of a positive relationship between the two variables. The Figure 2 of time series suggests a relationship with a delay. it seems to be true because of the specificity of variables. As it have been mentioned before in the first part of the sample there was irregular frequency of data combined with the effect of the global crisis. Thus the study have been focused on the time period from 2010.09 to 2014.04.

---

where:

$l_1, l_2, l_3, l_4 \ldots l_{16}$– the number of transactions carried out in each city, St– the sum of transactions made in all cities,

$C_1, C_2, C_3, C_4 \ldots C_{16}$– the price of one square meter of housing in individual cities, calculated according to the formula:

$Cena = (m_1 \cdot 0{,}5) + (m_2 \cdot 0{,}3) + (m_3 \cdot 0{,}2)$

where:

m_1 - median value of one square meter in the last calendar month,

m_2 - median value of one square meter in a month ($m_1 - 1$),

m_3 - median value of one square meter in a month ($m_1 - 2$).

[2] IZK_t – the index built on the basis of data containing median of creditworthiness for a family (2 + 1) with an income of 5 thousand zł net collected by the Lion's House. Credit for 30 years, buying real estate in the city with a population of 150 thousand.

The examination of the stationarity for ICN_t and IZK_t

The integration testing of the time series was made on the basis of the Dickey-Fuller'a test and autocorrelation function (Majsterek 2014) in Eviews. Both time series occur to be stationary on the first difference and are integrated I(1).

Figure 3. The time series ICN in the periods 2010.09 – 2014.04
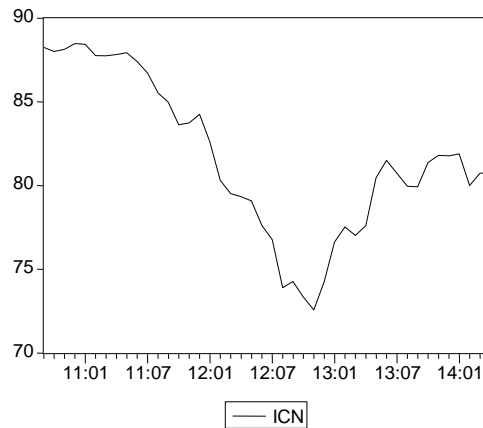
Source: own preparations

Table 1. ADF test for the ICN_t in the periods 2010.09 – 2014.04

ADF Test Statistic	-1.537272	1% Critical Value*	-3.5930
		5% Critical Value	-2.9320
		10% Critical Value	-2.6039
*MacKinnon critical values for rejection of hypothesis of a unit root.			

Source: own calculations in program Eviews

Time series of the index of real estate prices ICN_t is nonstationary on level. The value of the augmented Dickey-Fuller test ADF (-1.5372), exceeds the critical values for the low level of significance (Table 1).

Table 2. ADF test for the first difference of ICN_t in the periods 2010.09 – 2014.04

ADF Test Statistic	-4.040223	1% Critical Value*	-3.597
		5% Critical Value	-2.934
		10% Critical Value	-2.605
*MacKinnon critical values for rejection of hypothesis of a unit root.			

Source: own calculations in program Eviews

The time series of ICN_t seems to be integrated on the first difference because the value of the ADF test (-4.0402) is less than the critical value (Table 2).

Analysis of the autocorrelation function for levels and first difference of ICN_t conducts to the same conclusions. Autocorrelation function takes a sinusoidal shape for level of ICN_t, while for the first difference the autocorrelation function is fading.

Figure 4. The time series IZK in the periods 2010.09 – 2014.04
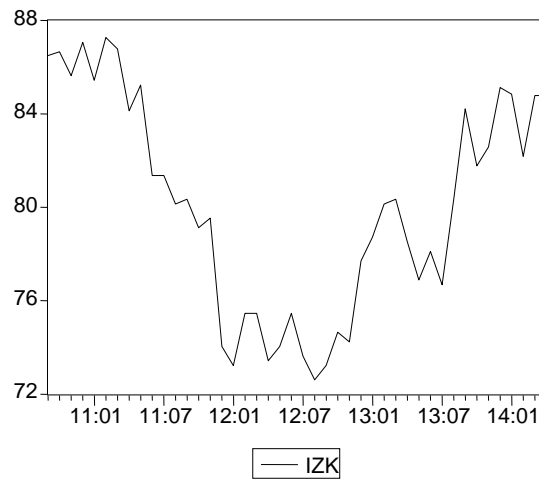
Source: own preparations in program Eviews

The time series of creditworthiness IZK has a similar course in time to the ICN in the considered period. Testing for integration has been carried out below:

Table 3. ADF test for the IZK_t in the periods 2010.09 – 2014.04

ADF Test Statistic	-1.475296	1% Critical Value*	-3.593
		5% Critical Value	-2.932
		10% Critical Value	-2.604
*MacKinnon critical values for rejection of hypothesis of a unit root.			

Source: own calculations in program Eviews

     A study for the level of IZKt confirms nonstationarity. The value of the ADF test (-1.4753) does not allow to reject the null hypothesis of the presence of unit root (Table 3).

Table 4. ADF test for the first difference of IZK_t in the periods 2010.09 – 2014.04

| ADF Test Statistic	-5.162493	1% Critical Value*	-3.597
		5% Critical Value	-2.934
		10% Critical Value	-2.605
*MacKinnon critical values for rejection of hypothesis of a unit root.			

Source: own calculations in program Eviews

Due to the augmented Dickey-Fuller test (Table 4) the time series IZKt seems to be integrated I(1) in the first difference. The integration of the two series in the first difference with the previously cited theory and charts has led the author to verify the cointegrating relationship. Other recommended in the econometrics literature tests like KPSS or integrated test of Durbin-Watson lead to the same conclusions in this case. Further analysis will be based on the Engle-Granger's and Johansen's procedures.

The long-term regression between variables ICN_t i IZK_t

The regression model posibly describing the long-term equilibrium was carried out in the program Eviews. Due to the specificities of the exogenous variable, IZK was lagged.

Figure 5. Indexes of the real estate prices and the 1 month lagged creditworthiness
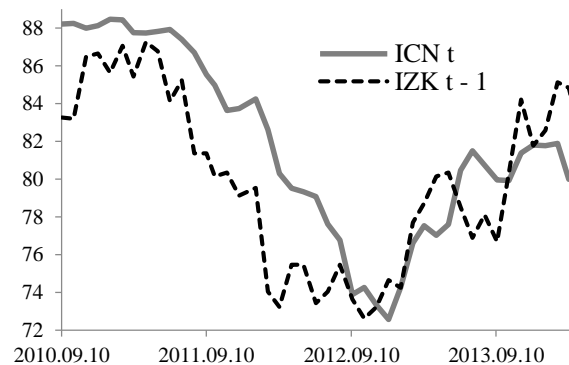
Source: own preparations

After a long modeling the long-term relation the author decided that the optimal lag for the variable IZKt is one month. This means that the change of index IZKt causes the adjustment of ICNt after one month. Models built for other lags showed worse statistical properties (both smaller R-squared and values of t-Student statistics for parameters). It seems that the dependence between the index of creditworthiness IZK and the index of real estate prices ICN without lags is unrealistic. The real estate market requires time to react to changes of the demand.

The index of creditworthiness is undoubtedly an important factor in creating the demand for housing. Although the impulse of change is "recognize by the market," with an average of 1 month delay. It is a quite quick response, but still delayed.

Table 5. The long-term relation between IZK_t and ICN_t in the period 2010.09 – 2014.04

Dependent Variable: ICN
Method: LeastSquares
Date: 05/10/16   Time: 14:44
Sample: 2010M09 2014M04
Includedobservations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IZK(-1)	0.667301	0.072611	9.190123	0.0000
C	35.93121	6.285064	5.716919	0.0000
T	-0.172769	0.025951	-6.657564	0.0000
R-squared	0.823165	Mean dependent var		81.80936
Adjusted R-squared	0.814538	S.D. dependent var		4.784893
S.E. of regression	2.060626	Akaike info criterion		4.349643
Sum squaredresid	174.0934	Schwarz criterion		4.471292
Log likelihood	-92.69215	Hannan-Quinn criter.		4.394756
F-statistic	95.42699	Durbin-Watson stat		0.602274
Prob(F-statistic)	0.000000			

Source: own calculations in program Eviews

The estimated model (Table 5) is characterized by fairly high R-squared value. The relationship describing the potential long-term relationship can be written as:

$$ICN_t = 0.667\ IZK_{t-1} + 35.931 - 0.173\ t$$

The increase in the index of creditworthiness IZK_t by one point in the past period t-1 (a month earlier) results in an average increase in the price index of real estate ICN_t about 0.667 point, assuming ceteris paribus. This regression (Table 5) is characterized by quite high fit to the empirical data (Adjusted R-squared: 0.8145). We can say that more than 81% of the variation of the ICN_t have been explained by the variation of the IZK_t and a variable showing a deterministic trend [Borkowski 2007].

The next stage of the research will become the verification of previously built long-term relationships with the ADF test for residuals. According to the Engle-Granger's procedure, the correct long-term relationship should generate stationary residual [Maddala 2006]. Stationarity of residual is an evidence of a linear combination of nonstationary variables which represents the cointegrating vector based on the theory of economy.

The examination of the stationarity for residuals of the long-term relation

The examination of the stationarity for aproprate residuals performed using the augmented unit root test ADF (Augmented Dickey Fuller) and the autocorrelation function. The stationarity testing of residuals can answer to the question of the existence of a long-term relationship [Syczewska 1999]. In case of the nonstationarity of residuals the long-term relationship turns out to be completely untrue.

Table 6. ADF test for residual series from the long-term regression

Null Hypothesis: RESZTY has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.706089	0.0080
Test criticalvalues:	1% level	-2.619851	
	5% level	-1.948686	
	10% level	-1.612036	

*MacKinnon (1996) one-sided p-values.

Source: own calculations in program Eviews

Table 6 indicates that the residuals generated by the built model are stationary. Thus, the relationship between the index of creditworthiness IZK_t and the index of real estate prices ICN_t is essentially a long-term dependency. Examined variables ICN_t and IZK_t are cointegrated. In this situation, the long-term parameter 0.667 can be interpreted as the elasticity of the long-term relation (Table 5). The alternative approach for modeling nonstationary time series are models VAR with the Johansen's cointegration test.

The VAR relation between ICN_t and IZK_t

The VAR model was built with 1 month lag. VAR with higher lag showed a total lack of statistically significant coefficients for variables delayed more than 1 month. Moreover statistically insignificant were constant and deterministic trend. Coefficients from the VAR model are consistent with the theory of economy. Noteworthy is a very strong influence of changes in real estate prices ICN from the previous month to its current value.

Table 7. Model VAR for variables ICN_t i IZK_t

VectorAutoregressionEstimates
Date: 05/10/16   Time: 10:53
Sample: 2010M09 2014M04
Includedobservations: 44
Standard errors in ( ) & t-statistics in [ ]

	ICN	IZK
ICN(-1)	0.826582	0.017442
	(0.04075)	(0.08914)
	[20.2853]	[0.19567]
IZK(-1)	0.175419	0.982276
	(0.04176)	(0.09136)
	[4.20050]	[10.7519]
R-squared	0.962724	0.808747
Adj. R-squared	0.961837	0.804193
Sum sq. resids	36.69769	175.6247
S.E. equation	0.934748	2.044881
F-statistic	1084.740	177.6042
Log likelihood	-58.44083	-92.88481
Akaike AIC	2.747310	4.312946
Schwarz SC	2.828410	4.394045
Mean dependent	81.80936	80.04843
S.D. dependent	4.784893	4.621194
Determinant resid covariance (dof adj.)		3.618250
Determinant residcovariance		3.296794
Log likelihood		-151.1115
Akaikeinformationcriterion		7.050523
Schwarz criterion		7.212722

Source: own calculations in program Eviews

The analytical formula of the built VAR model is shown below:
$ICN_t = 0.827 * ICN_{(t-1)} + 0.175 * IZK_{(t-1)}$
$IZK_t = 0.017 * ICN_{(t-1)} + 0.982 * IZK_{(t-1)}$

   The first equation of the VAR model is consistent with the assumptions of the theory of economy (ICN is dependent on changes in real estate prices and the changes in the creditworthiness IZK in the previous month). The second equation seems to be contrary to theory of economy. The variables are nonstationary on levels and integrated in the first differences, hence VEC model was built. The VEC model has correct adjustment coefficients (negative sign), but in many cases the large standard errors of short-term flexibility coefficients. The upper part of the

Table 8 shows the scalar of cointegration equal to 1.014. Moreover the value 1.014 has a very small standard error of the estimation (0.0098), hence quite high the absolute value of the t-Student statistic (-103.453). On this basis, the estimation of the long-term relationship between ICN and IZK seems to be statistically significant.

Table 8. Model VEC for variables ICN_t i IZK_t

CointegratingEq	CointEq1	
ICN(-1)	1.000000	
IZK(-1)	-1.014261	
	(0.00980)	
	(-103.453)	
Error Correction:	D(ICN)	D(IZK)
CointEq1	-0.175698	-0.033616
	(0.04661)	(0.10461)
	(-3.76943)	(-0.32136)
D(ICN(-1))	0.195882	-0.136484
	(0.13057)	(0.29304)
	(1.50015)	(-0.46575)
D(IZK(-1))	-0.059036	-0.144421
	(0.08124)	(0.18231)
	(-0.72672)	(-0.79216)
R-squared	0.346156	0.019215
Adj. R-squared	0.314261	-0.028628
Sum sq. resids	34.22215	172.3617
S.E. equation	0.913612	2.050352
F-statistic	10.85304	0.401632
Log likelihood	-56.90433	-92.47221
Akaike AIC	2.722924	4.339646
Schwarz SC	2.844573	4.461295

Source: own calculations in program Eviews

In addition, the number of cointegration vectors has been tested on the basis of the Johansen's test (Kusideł 2000).

Table 9. The Johansen's cointegration test for variables ICN_t i IZK_t.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.257429	13.09698	12.32090	0.0370
At most 1	2.22E-05	0.000975	4.129906	0.9814

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: own calculations in program Eviews

Table 9 shows that there is only one vector cointegration, thus in the long term is correct relationship consistent with the theory of economy. It has been estimated the value of the long-term parameter equal to 1.014 (Table 8) in Eviews program. This is the higher value than the apropriate coefficient nfrom the Engle-Granger's procedure. However, the sign of coefficient is correct from both procedures (reffering the sign to the market's mechanisms and the theory of economy).

SUMMARY

1. In the period from 2010.09 to 2014.04, we can confirm the thesis about the existence of cointegration relationship between the real estate price index (ICNt) and the index of creditworthiness (IZKt).
2. The dependence of both indexes requires apropriate lags. In the case of the real estate market it turned out that the "effect of adjustment" will take 1 month (when the change of the creditworthiness led to a correction in prices).
3. The VAR model and the Johansen's procedure led to estimation of the long-term flexibility equal to 1.014. Thus, an increase in the index of creditworthiness IZKt by one percentage point causes an average increase in the price index of real estate ICNt about 1.014 percentage point with a 1 month lag.

The value more than 1 of coefficient for the long-term relation may indicate a process conducive to speculative bubbles in the real estate market (the price index grows faster than the index of creditworthiness). On the other hand, the coefficient of long-term relation is less than one on the basis of the Engle-Granger's procedure. The Johansen's procedure based on the VAR modeling is considered to be more reliable tool in empirical researches [Welfe 2009].

REFERENCES

Borkowski B., Dudek H., Szczesny W. (2007) Ekonometria, wybrane zagadnienia. PWN.

Bryx M. (2006). Wybrane aspekty finansowania i organizacji rynku nieruchomości. SGH Oficyna Wydawnicza.

Charemza W., Deadman D. (1997) Nowa ekonometria. PWE.

Enders W. (2003) Applied Econometric Time Series. John Wiley & Sons.

Franses P. H., De Groot B. (2013) Do commercial real estate prices have predictive content for GDP? Taylor & Francis.

Gajda J. (2004) Ekonometria. C.H. BECK.

Kusideł E. (2000) Modele wektorowo-autoregresyjne VAR metodologia i zastosowania. Absolwent.

Maddala G.S. (2006) Ekonometria. Warszawa, PWN.

Majsterek M. (2014) Modelowanie systemów skointegrowanych. Aspekty teoretyczne. Bank i Kredyt 45(5),.

Syczewska E. (1999) Analiza relacji długookresowych: estymacja i weryfikacja. Szkoła Główna Handlowa.

Welfe A. (2009) Ekonometria. Polskie Wydawnictwo Ekonomiczne.