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Residential property price forecasts within a short-sample environment

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Residential property price forecasts within a short-sample environment

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Abstract

This article documents a method used by the Národná banka Slovenska in the Eurosystem projection process for the purpose of creating a forecast regarding the average price level of housing in the Slovak Republic. It also describes the analytical model applied to this end. Since available quarterly data only dates back to the first quarter of 2005, the application of standard econometric procedures provides questionable values of estimated parameters. For this reason, the selected approach uses calibrated elasticities of house prices with respect to various determinants from various international sources and based on this develops a single equation error correction model. Using NBS' and other forecasts of individual explanatory variables, the model is able to yield house price forecasts for the required period. Forecast evaluation shows some encouraging results since ex-post one step ahead forecasts and to some extent also medium term dynamic ex post forecasts do not deviate from the actual price observations.

Keywords: real estate market, forecasts, error correction model, calibration, forecast precision evaluation

Introduction

In the past, models of real estate prices (also referred to for brevity as house prices) were created for a large number of countries, especially from among OECD members. They are typically based on four or five determinants which, according to economic theories, should have a significant influence on prices. The aim of this analysis is to identify an appropriate function defining the relationship between price[1] and individual determinants, to estimate their respective coefficients indicating the strength of their impacts on prices, and finally, to produce forecasts with a 2-3 years horizon. The result is a simple linear model, the reliability of which is at the stage of testing, and predictions of which need to be seen as orientational, theoretical, and in progress, also with regards to all the future outlooks in the attached charts.

A large number of academic studies deal with identifying the main indicators that could be used for such purposes. On the basis of their findings, a simple model based on quarterly time series was created for Slovakia, containing the following main determinants[2] of real house prices:

- The real gross disposable household income (*ry*), seasonally adjusted;
- The real interest rate (*R*) on new loans to households for housing purchases[3];
- Housing supply, measured by the sum of seasonally adjusted numbers of dwellings under construction and completed (*h*);
- The number of inhabitants in the age band 25-40 years as an additional demand indicator (*pop*).

1. The theory of real estate price determination

Academic literature typically points to the theory that house prices are being driven by a fundamental relation which determines the equilibrium price. However, there are drivers which often cause deviations from this equilibrium, mainly investor expectations. For example, during an economic expansion, growing incomes cause an increase of equilibrium prices that consequently positively impact price and capital gains expectations, leading to excessive price increases. The contrary phenomenon can occur in a period of recession.

On the basis of this theory, one can assume that there exists an equilibrium price around which the actual price fluctuates and thus creates higher volatility than could be expected based on fundamental relationships only. The determinants mentioned in the introduction should affect mainly the equilibrium price (although their short-term fluctuations could also

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[1] Residential property prices – the Slovak average – published quarterly on the NBS website: http://www.nbs.sk/sk/statisticke-udaje/vybrane-makroekonomicke-ukazovatele

[2] Some authors also use real volume of loans. Due to this we include below the following two alternative methods of creating price forecasts: one without applying the volume of loans and one including this variable while it is expressed as the volume of loans to households divided by the gross disposable household income (*l/y*). The model is thus capable of depicting to a certain extent the adequacy of loan supply relative to incomes as well some imperfection in the credit market resulting in interest rates not fully reflecting the development of demand and supply in this market.

[3] The real interest rate can be calculated by subtracting the core inflation rate (the annual HICP inflation rate without unprocessed food and energy) from the nominal interest rate on new loans for property purchase in the relevant quarter. The reason for using the core HICP is its substanially lower volatility compared to the standard HICP.

cause a deviation of actual prices from equilibrium). However, it also needs to be noted that currently no time series of prices exists that would be long enough to clearly indicate that under-evaluations or over-evaluations are characteristic or very significant for the Slovak market.

2. The method of estimation

In order to obtain the forecast, it is first necessary to estimate the coefficients in the following equation:

$$\textbf{(1)}\quad rh\hat{p}_t = \hat{m}_0 + \hat{m}_1 ry_t + \hat{m}_2 R_t + \hat{m}_3 h_t + \hat{m}_4 pop_t + \hat{m}_5 (l/y)_t \ ^{4}$$

After substituting in for the variables on the right hand side of the equation, we obtain an estimate of the equilibrium price. We could proceed in the same way when forecasting: the predicted values of the right hand side variables will be substituted in the equation and we will obtain the equilibrium house price forecast.

The actual estimation can be realised by the method of least squares (OLS)[5]. This method has been applied in several studies, since it captures the essence of the relationship in question: residential property prices are an endogenous variable, which is being influenced to various extents by five main exogenous determinants. Subsequently, the model can be extended by a disequilibrium component using the error correction model (ECM) described in Part 5.1. More complex models require more information on the right side of the equation, which is impossible in the case of a short sample. The same can be said about multiple equation methods.

Due to the above reasons, the simple OLS approach seems appropriate for estimation purposes although some potential problems will persist. The reason for this is the aforementioned short sample, and the non-standard development of the Slovak housing market in the given period (an almost uninterrupted real price growth). The estimated elasticities could therefore misleadingly attribute the price increases to the incorrect determinants and this could be avoided only with a substantially longer time series with a greater variability of the house price dynamics.

The following section will describe the OLS estimation results. Since these do not appear to be reliable, an alternative approach will also be presented, making use of the **μ** coefficients from various international sources, whose methodology and countries observed would be relevant in case of Slovakia.

3. Estimation results

Estimation in this case is severely affected by the sample length. As a result, the parameter estimates may be very unstable and change abruptly with each new observation and with each

[4] *Rhp* = real house prices, i.e. the average price per m^2 expressed in constant prices of 2005 applying the core HICP. All variables except *R* enter the model in the form of a natural logarithm.

[5] A more precise method that could be used in this case is the method of fully modified ordinary least squares (FMOLS) which in contrast to the standard OLS method enables correct estimation of the variance for individual estimates of the μ coefficients and to carry out correct hypothesis testing. In our case, however, the standard and modified version of the OLS did not provide significantly different parameter estimates (hypothesis testing provided the same conclusions), therefore we provide as an approximation only the results of the OLS method. The author can provide the results of the FMOLS on request.

change in the number or nature of the explanatory variables. The low number of degrees of freedom will result in parameter estimates that can be very distant from approximate true impacts of exogenous variables on house prices. These unreliable elasticity estimates can have further negative impacts on the estimation outcomes, namely non-stationary residuals and finally ECM results, whereby the sign of the error correction term might be positive and perhaps insignificant. The outputs below illustrate the nature of the problems stemming from the short data sample.

When searching for the optimal relationship, a model based on equation (1) using the OLS was estimated first, incorporating a linear time trend (in order to account for the different time trends in the individual variables) (Table 1).

Table 1

Dependent variable: LOG(RHP)
Method: Ordinary Least Squares
Sample: 2005Q1 2009Q3
Number of included observations: 19

	Coefficient	Standard deviation	t-statistic	p-value
C	18.039	86.273	0.209	0.8379
@TREND	0.011	0.049	0.229	0.8231
LOG(RY)	1.732	0.461	3.758	0.0027
IR_REAL	-0.057	0.012	-4.900	0.0004
LOG(H)	-1.340	0.319	-4.195	0.0012
LOG(POP)	-1.649	12.279	-0.134	0.8954
LOG(LY)	0.606	0.276	2.198	0.0483

R^2	0.990	Average LOG (RHP)	7.010
Adjusted R^2	0.986	LOG (RHP) st. dev.	0.189
F-statistic	207.794	Durbin-Watson	1.332
F-statistic (p-value)	0		

The parameter magnitudes and signs are as expected, except for population. Since the time trend is also statistically insignificant, we have also estimated an alternative equation without the trend (Table 2). In this case, all the estimated coefficients are in line with expectations[6]. However, if we estimate the same model for the period from 2005Q1 through 2009Q2, the elasticities will change rather sharply (*pop* will increase to 4.44, *ry* will fall to 1.43, and *h* will fall to -1.54).

Next, it is necessary to verify if the residuals are stationary. If results with the full sample are considered again, the outcome will be that the residuals are non-stationary I(1). That would mean that no equilibrium relationship between the given variables exists, which would not be acceptable from a theoretical point of view. If, in spite of this, we estimate the full ECM model (to explain short-term movement of prices), the result will be a positive and

[6] The only exception is the insignificant estimate of population elasticity. Since its absolute value is comparable with other parameters, we will not ignore its influence. Another problem of the estimation is the impossibility to verify the order of integration of variables. Some seem to behave as I(2) which is relatively unusual. On the other hand, other variables are stationary. We believe this problem can be assigned to the short sample and we continue in the analysis of these results with the aim of illustrating further problematic results.

insignificant coefficient of the error correction term, which is unsatisfactory from a modeling and forecasting perspective[7].

Table 2				
Method: Ordinary Least Squares				
Sample: 2005Q1 2009Q3				
Number of included observations: 19				
	Coefficient	Standard deviation	t-statistic	p-value
C	-1.153	18.983	-0.061	0.9525
LOG(RY)	1.769	0.414	4.271	0.0009
IR_REAL	-0.056	0.008	-6.790	0.0000
LOG(H)	-1.343	0.307	-4.370	0.0008
LOG(POP)	1.036	3.437	0.301	0.7679
LOG(LY)	0.664	0.100	6.671	0.0000
R^2	0.990	average LOG (RHP)		7.010
Adjusted R^2	0.987	LOG (RHP) st. dev.		0.189
F-statistic	268.950	Durbin-Watson		1.314
F-statistic (p-value)	0.000			

Overall, the indicated estimation techniques reveal several shortcomings. The estimated parameters show significant instability. In order to identify the main determinants of the house price movements in the past and in the future, we would need more stable values, which could potentially be achieved with a longer sample. Moreover, it is impossible to prove the existence of an equilibrium relationship between house prices and the individual determinants when using the ECM model and the test of residual stationarity. Due to the stated reasons, house price forecasts and statistical inference based on econometric results are not useful[8]. The likely reason for these outcomes is the short sample size: house prices in the given period grew very dynamically and almost uninterruptedly, therefore there was not enough time to capture the influences of individual determinants.

4. An alternative approach – the selection of appropriate coefficients

Econometric estimation for the time being does not enable us to make reliable predictions. An alternative option, however, is calibration – adopting elasticities estimated in other relevant studies investigating the relationship between real estate prices and their determinants. Each of the coefficients in Table 3 expresses the calibrated elasticity for the Slovak Republic[9]:

Table 3		
Variable	**Coefficient**	**Reasons for selection of the given value**
ry	1	Values around 1 are dominating in a large number of studies.
R	-0.01	The elasticity value reaches -0.036 on average, based on IMF research review of OECD countries.[10] After

[7] The results of the residual stationarity test and the ECM model are presented in Appendix B.
[8] Similar outcomes have been achieved when omitting the alternative indicator (*l/y*).
[9] A list of research studies on the basis of which the coefficients were selected is presented in the bibliography and in more detail in Appendix A. It will be gradually revised and the conclusions will be adjusted accordingly.
[10] Iossifov et al. (2008)

Table 3		
Variable	Coefficient	Reasons for selection of the given value
		substituting in, the estimated contributions of ***R*** to *rhp* growth seem too large relative to the other determinants, therefore this value was not accepted. One of the few studies focusing on central and eastern Europe (CEE) estimates the elasticity as -0.01.[11]
pop	4.45	The literature provides a relatively uniform conclusion that the elasticity with respect to population growth is large One can often find values above 10 although in the Slovak data this would probably lead to incorrect estimates. For this reason, we chose the value 4.45, originating from Egert and Mihaljek's analysis of OECD countries[11] and maintaining the relative strength compared with the other determinants' elasticities.
l/y	0.24	This coefficient is again taken from the CEE study [11], which uses the same indicator.
h	-0.5	The IMF research review [10] indicates that the elasticity normally ranges from -1 to -3. However, after substituting the average value of -2 into the equilibrium equation for Slovakia, the resulting equilibrium prices oscillate excessively compared with actual prices and, moreover, the housing supply coefficient forces a long term negative trend upon the real equilibrium house prices, which is not consistent with the observed trend and a converging economy development. These problems are eliminated once a weaker coefficient of -0.5 is used.

5. The forecasts[12]

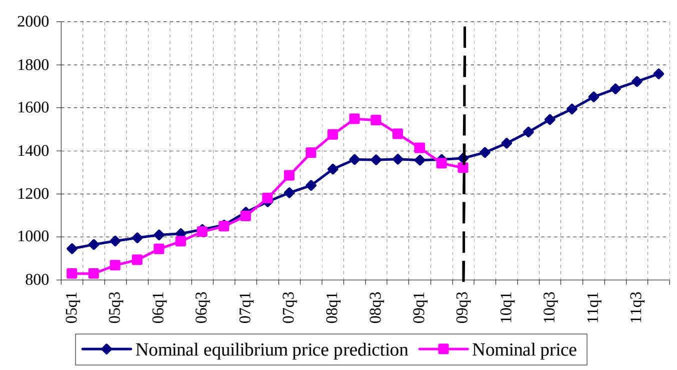
Equilibrium price was estimated for each quarter within the period from 2005Q1 to 2009Q3[13]. It is a period for which actual observations were available for all variables within the model. Equilibrium prices will be compared with actual prices for the given period. Forecasts of equilibrium prices for the period from 2009Q4 to 2011Q4 will also be provided.[14]

Up to 2009Q3, the determinants are represented by their actual values. From 2009Q4, the actual data do not exist, we will, therefore, use their forecasts[15]. According to the estimated

[11] Égert, Mihaljek (2008), „Determinants of House Prices in Central and Eastern Europe"; Czech National Bank Working Paper Series.
[12] Without the variable *l/y*. Chapter 6 includes this variable.
[13] The article makes use of the data (including the forecasts of this data) available in the 4th quarter of 2009. At the time of publication of this article, more up to date observations of individual variables and their forecasts exist.
[14] Data on nominal prices come from the website of the NBS. We can obtain real prices by deflating the nominal prices by the core HICP index. The model generates forecasts of real prices. Consequently, nominal forecasts may be calculated by a reverse application of the forecasts of core HICP for Slovakia for 2009 through 2011 from Eurosystem predictions.
[15] *ry* – the NBS creates its own forecasts. ***R*** – the forecast is based on the assumptions of the ECB (European Staff Macroeconomic Projections for the Euro Area, December 2009) regarding future EURIBOR rates; it is assumed that the nominal EURIBOR rates will be reflected in the nominal interest rates on housing loans. *Pop* - prediction is taken from the Research Demographic Centre of Infostat (www.infostat.sk/vdc). *h* – is the only variable for which no official forecasts exists. Therefore we applied the approach of a regression with lagged values of housing starts and the construction confidence indicator (Statistical Office of the Slovak Republic) and the remaining quarters were predicted using a simple ARIMA model with final expert modification.

equilibrium relationship (Equation 1 and Table 3), in 2009Q3 the nominal equilibrium prices increased (EUR 1,366 per m^2) after more than one year of stagnation and should subsequently increase towards EUR 1,757 per m^2 which is 33% higher than the actual price in 2009Q3 (EUR 1,322 per m^2). The prices at present seem to be just below their equilibrium level (by 3%).

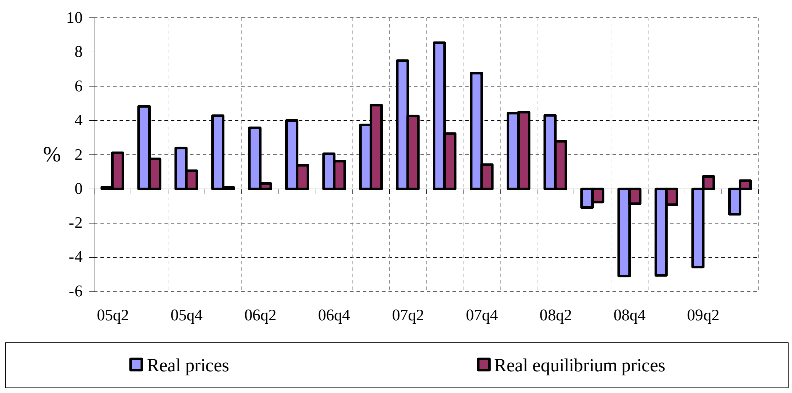
Chart 1: Nominal prices (EUR/m2)



Source: author's own calculations (applies for all charts in this article).

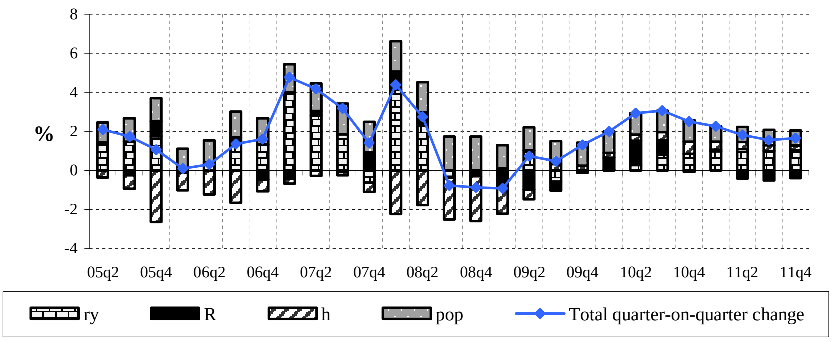
Chart 1 depicts a relatively close relationship between the equilibrium predicition and the actual price, although with visible under- and overvaluation (undervaluation of 14% in mid-2005 and overvaluation of a similar extent in mid-2008). The growth rates of these two variables are compared in Chart 2 on a quarter-on-quarter basis.

Chart 2: Quarterly growth rates



Real growth rates are in general characterised by the same direction as their equilibrium counterparts, with the exception of 2009Q2-Q3. According to Chart 1, we can also state that this estimation approximately captures the periods when prices were perceived as under- and overvalued. Quarter-on-quarter dynamics of the equilibrium prices can be decomposed according to the contributions of individual determinants. The contribution of each one of them is depicted in Chart 3.

Chart 3: Contributions to the quarter-on-quarter growth of real equilibrium prices (in %)



As one can see from Chart 1, a substantial gap between the estimate and reality was created in the period between 2008Q1 and Q3. According to Chart 3, the equilibrium price in the given period was negatively influenced by a significant increase in housing supply, which started to overshadow the contributions of income. The population grew more or less constantly during the whole period, thus positively affecting the price. The strongest impacts so far were stemming from income (which is considered to be an especially important price determinant). The influence of the real interest rate varied, depending on its coefficient and and changing level.

5.1 A detailed forecast description for the period 2009Q3 – 2011Q4

The above charts suggest that prices were exceeding their equilibrium from mid-2007 until the end of 2008, when a downward adjustment occurred. On the basis of this information, one could assume that the observed price was overvalued and it gradually adjusted towards equilibrium values. In the present environment of weak demand and pessimism regarding future capital gains, it can be assumed that the price will even undershoot its equilibrium value.

Chart 3 also depicts the influence of the determinants on the equilibrium price in the coming quarters. A significant weakening of the influence of supply on price is apparent. Supply should decline in the future as a result of the cooling real estate market, creating a slightly positive pressure on the equilibrium price. This future scenario can be foreseen by looking at the downward tendency of housing starts at present as well as extremely low levels of the construction confidence indicator. The current forecasts for *ry* suggest that the contribution of this variable to price growth will be visibly lower when compared to the recent past. The current level of interest rates can also support price growth in the future. The last indicator *(pop)* maintains an approximately constant growth trend, but later on, a slowdown is expected in the given category, in line with the available forecasts.

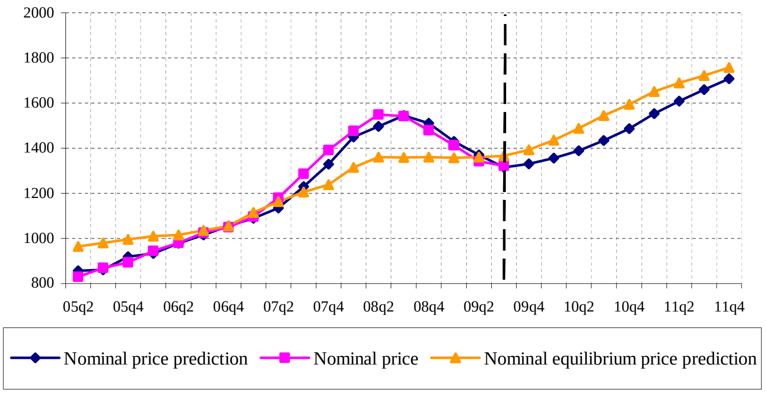
It is justified to ask how quickly the current actual price will achieve its equilibrium level, or, in the present situation, how long it will stay below this level. The ECM model is able to provide a theoretical answer, normally by observing a very long time span and calculating the expected speed of adjustment towards equilibrium. The model also takes into account the short run influences of all the determinants; in other words, even though the price in general returns towards equilibrium, in the short run it can be removed from this trajectory by immediate changes of the determinants.

Since standard econometric estimation provided unreliable results, we will again make use of calibrated parameters. The model has the following form:

$$\textbf{(2)}\ \ \Delta rhp_t = a_1(rhp_{t-1} - r\hat{hp}_{t-1}) + a_2\Delta ry_t + a_3\Delta rhp_{t-1}; a_1 < 0; a_3 \in (0;1)$$ [16]

Predictions of the actual nominal price and its estimated equilibrium, as well as the complete nominal and real time series until 2011 are provided in Charts 4 and 5.

Chart 4: Prediction using ECM (EUR/m2)



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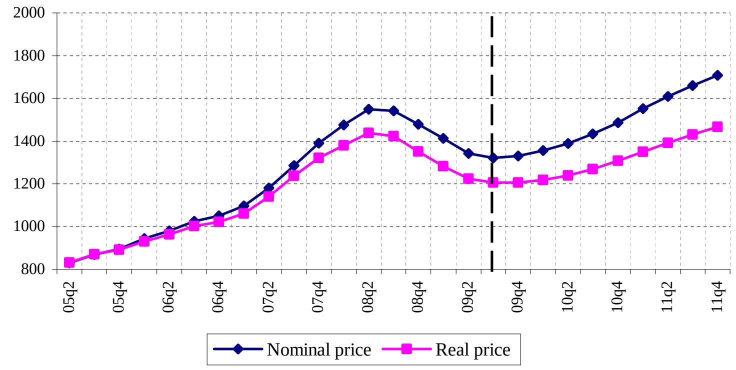
[16] Where Δ means quarter-on-quarter growth; $r\hat{hp}_{t-1}$ is the equilibrium price (estimated using the described method). The α3 coefficient lies in an open interval (0; 1) and expresses the inertia of house price growth or what is referred to as the feedback mechanism, whereby the growth trend of prices leads to further growth due to optimistic expectations, and the negative trend on the other hand magnifies the existing pessimism. This can contribute to more realistic price dynamics. The coefficients have the following values: α_1=-0.2 (as an approximate average from Lecat, Mesonnier(2005), „What role do financial factors play in house price dynamics?“ and Egert, Mihaljek (2008)); α_2=0.5 (from Lecat, Mesonnier (2005)); and α_3=0.44 as an average of several studies' findings – details presented in Appendix A.
The remaining determinants were assigned a zero short-term influence: an increase in population will probably only have an impact gradually and may not imply rising demand immediately; it is also assumed that increased supply will not be reflected in prices immediately since sellers probably need some time to adjust their desired price; in the case of interest rates, we assume that it also takes potential buyers a certain amount of time until the interest rate shock influences their decision to enter the market. There was not enough empirical evidence to determine the short run influence of *l/y*. Thanks to this structure, the model maintains its simplicity and transparency.

Chart 5: Hypothetical time series - prediction from 2009Q4 (EUR/m2)

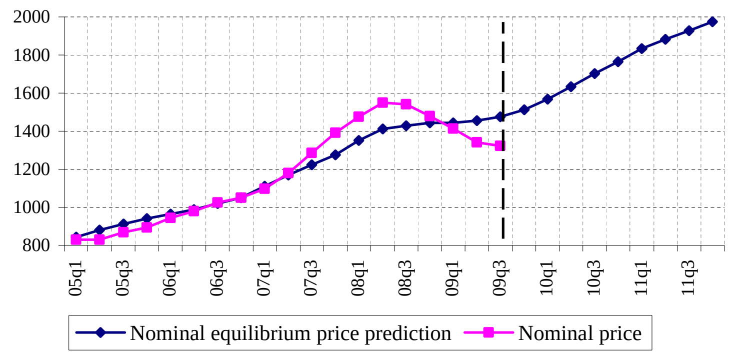


6. Model including the volume of loans provided

The model described in the previous part (model A) can be extended by including an additional explanatory variable (*l/y*)[17], which serves as another indicator of demand The estimate of equilibrium price then takes the form of equation (1), and the full ECM model will be estimated by applying equation (2).

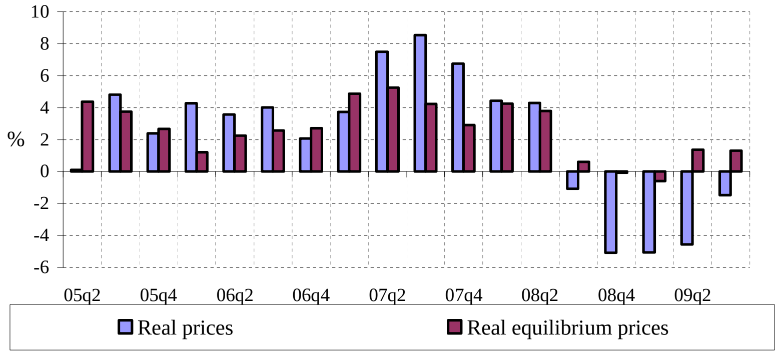
According to Chart 6 the equilibrium price continues to grow in the 4th quarter of 2009 following a period of stagnation in the second half of 2008 and at the beginning of 2009, and it subsequently grows to the level of EUR 1,975 per m^2, which is 49% higher than the price observed in the 3rd quarter of 2009. Therefore, this version of the model predicts a much steeper growth than model A. Moreover, the model suggests that the current observed price (in 2009Q3) is 10% lower compared to the equilibrium. The chart also shows a strong connection between equilibrium and actual prices, except for the 5 percent undervaluation in 2005 and an almost 10 percent overvaluation in mid-2008.

Chart 6: Nominal prices (EUR/m2)



[17] (*l/y*) expresses the ratio of household credit volume and gross household disposable income. We obtain future values of the variable l using internal forecasts of the NBS used in Eurosystem predictions.

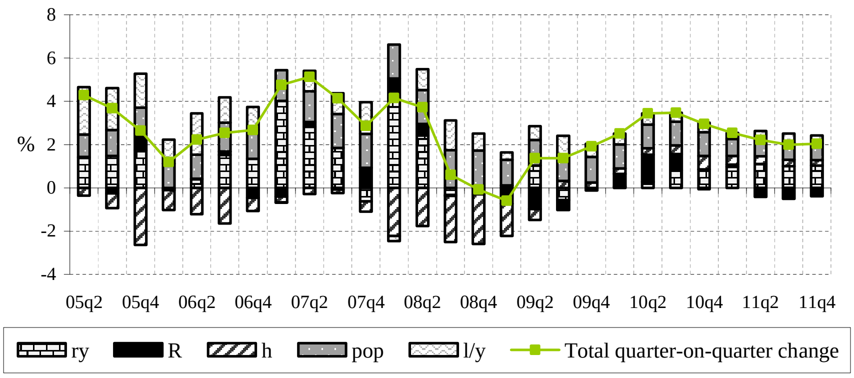
Chart 7: Quarterly growth rates



The quarterly growth rates of the two time series in Chart 7 were in general of a similar direction and magnitude, with the exception of the most recent quarters (when the actual price was returning back towards equilibrium and eventually undershot this level). This means that the inclusion of the credit indicator will yield estimates of equilibrium prices closer to actual prices than in the case of model A, while the capturing of under- and overvaluation is less evident.

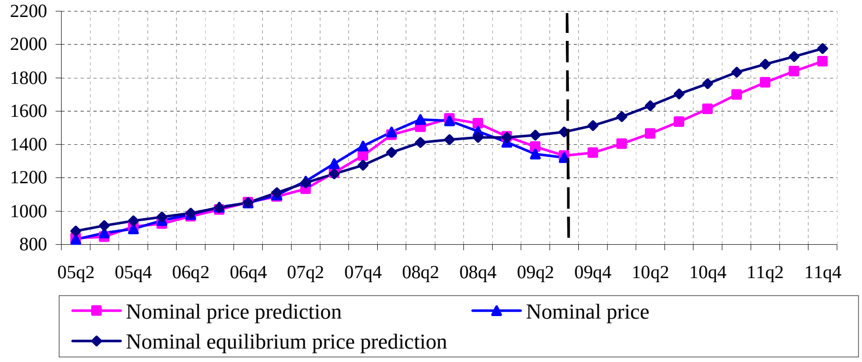
Chart 8 explains contributions of individual determinants to the equilibrium price growth. This time, the chart includes the pro-growth influence of the credit indicator, while the other indicators maintain the same contributions as before. Based on the current medium-term predictions, *l/y* will be characterised by a slowing, but continuingly positive dynamics and the associated contribution to price growth.

Chart 8: Contributions to the quarter-on-quarter growth of real equilibrium prices (in %)



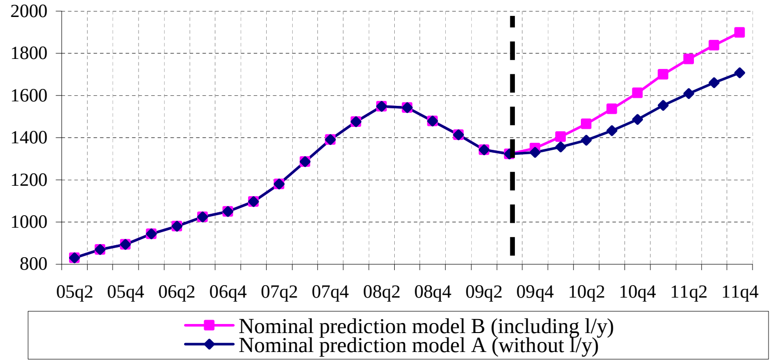
Overall, adding the volume of loans to the model will lead to a steeper actual price prediction path. This is confirmed when using the ECM equation for the upcoming quarters, which predicts an immediate market recovery starting in the 4th quarter of 2009, and continuing to develop dynamically in accordance with Chart 9.

Chart 9: Prediction using ECM (EUR/m2)



It is evident from the above that the prediction process eventually yields two sets of predictions (Chart 10). It is then up to the the forecaster to select the one that seems to be realistic, given the current state of the economy. Currently, a high level of uncertainty persists regarding the nature of recovery from the global recession, which may be protracted, immediately making the results of model A more likely. A longer recovery could also magnify the negative feedback in real estate prices and slow down the recovery of determinants such as income and supply of loans, leading to further downward pressure on real estate prices not captured in the equations discussed. A further downside risk to prices stems from the possible larger than expected excess supply in the Slovak residential property market, since we have observed a large number of new flats coming onto the market in the recent past and official statistics and models are not capable of confirming what is the precise extent of the excess and its price impacts. Due to these reasons, there is a need to perform expert adjustments to the selected price prediction trajectory based on important current information or other analyses. This approach is used by the NBS in its forecasts of real estate prices. It is necessary to point out that the presented model predictions are not official predictions of the NBS, and the results need to be considered as orientational and entirely theoretical, while their reliability will continue to be tested.

Chart 10: Predictions using ECM – summary (EUR/m^2)



7. Forecast evaluation

The available data enable the evaluation of the "one step ahead" forecast precision for a substantial part of the sample (2005Q3 – 2009Q3), and also the evaluation of the dynamic ex post forecasts for several steps ahead. The latter involves making a long term forecast at a selected point in the past (e.g. in 2005Q2 for the period 2005Q3 – 2009Q3), while disregarding actual observations of real estate prices over the forecast period. On the other hand, actual observations of determinants will be used instead of their individual forecasts. This allows us to isolate the performance of the model parameters from the imprecision brought into play by imperfect determinant forecasts.

7.1 One-step-ahead forecast

The performance of short-term predictions of models A and B is depicted in Charts 4 and 9 respectively[18], immediately suggesting a good level of precision regarding prices for the coming quarter. Table 4 provides some traditional accuracy statistics.

Table 4: Forecast accuracy statistics

	Model A	Model B
Correlation coefficient [19] (Corr)	0.86	0.90
Mean absolute percentage error (MAPE)[20]	1.84	2.18
Theil inequality coefficient [21] (Theil)	0.51	0.55
Bias proportion (Um)	0.13	0.10
Variance proportion (Us)	0.34	0.67
Covariance proportion (Uc)	0.54	0.23

Chart 11.1: Quarter-on-quarter change of real price, model A (in %)

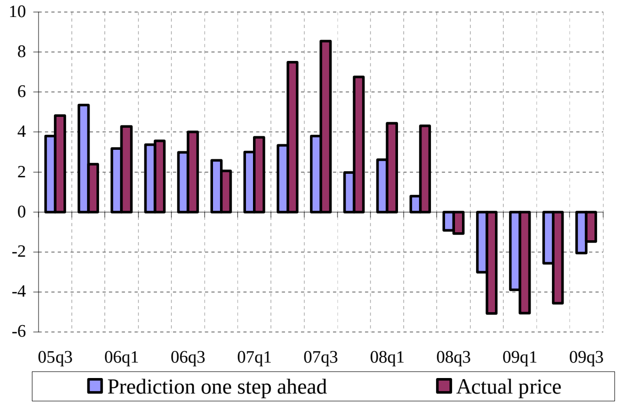


Chart 11.2: Quarter-on-quarter change of real price, model B (in %)

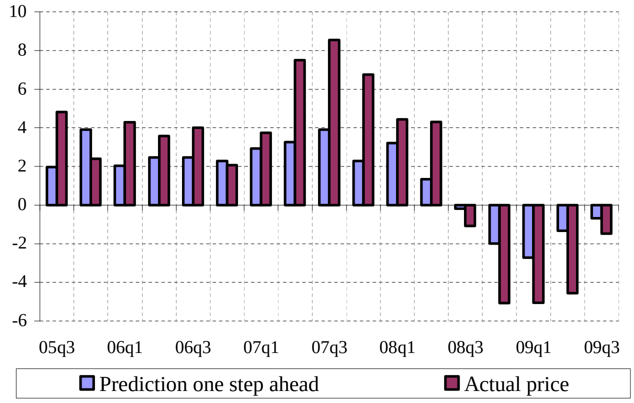


Chart 11 indicates that the predicted growth rates always have the correct sign and their magnitude is approximately correct, even though there are several exceptions. This regularity is confirmed by the accuracy statistics in Table 4. The correlation between predictions and actual values is relatively strong. MAPE shows a minor percentage deviation of actual values from their forecasts, and the Theil coefficient proves that the models dominate a naive prediction of zero change. It is positive that Um is close to zero in both cases. However, the

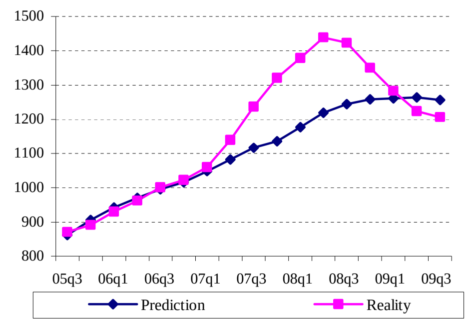
[18] In these charts, the one step ahead forecasts for the period from 2005Q2 to 2009Q3 are expressed by the nominal price prediction curve for this period.
[19] Correlation between predicted and actual quarter-on-quarter growth rates.
[20] For example Pindyck, Rubinfeld (1991). Calculated from price levels.
[21] For example Watson, Teelucksingh (2002). The value of the coefficient greater than 1 means that the prediction is worse than a "naive" forecast with zero future growth, while values declining from 1 to zero signal movement from a naive forecast to a forecast with perfect precision.

Us is relatively high, especially in the case of model B. Despite this, the results are satisfactory overall.

7.2 Medium-term forecasts

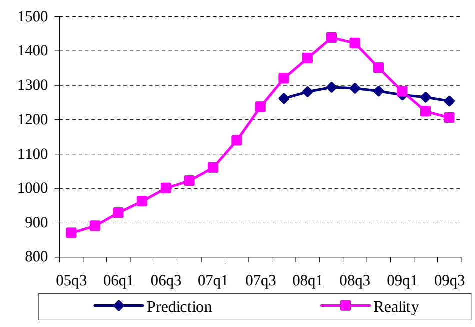
A further step will be to compare the forecasts for several quarters with actual prices. Three important points in the previous cycle were selected for this purpose (2005Q2 – 1st case: bottom of the previous cycle, 2007Q3[22] – 2nd case: strengthening of the residential boom and 2008Q2 – 3rd case: peak of the cycle) and in each case, prediction for the following period until 2009Q3 was created. The results of model A are described in Chart 12[23].

Chart 12.1: Medium-term forecast 2005Q2, real prices (in EUR per m²)



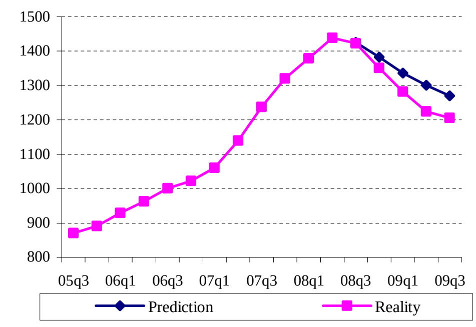
Corr	MAPE	Theil	Um	Us	Uc
0.70	5.54	0.69	0.003	0.66	0.34

Chart 12.2: Medium-term forecast 2007Q3, real prices (in EUR per m²)



Corr	MAPE	Theil	Um	Us	Uc
0.95	5.50	0.78	0.01	0.94	0.04
0.69	6.25	0.62	0.11	0.55	0.33

Chart 12.3: Medium-term forecast 2008Q2, real prices (in EUR per m²)



Corr	MAPE	Theil	Um	Us	Uc
0.84	3.66	0.40	0.41	0.38	0.21
0.80	4.62	0.57	0.16	0.40	0.44

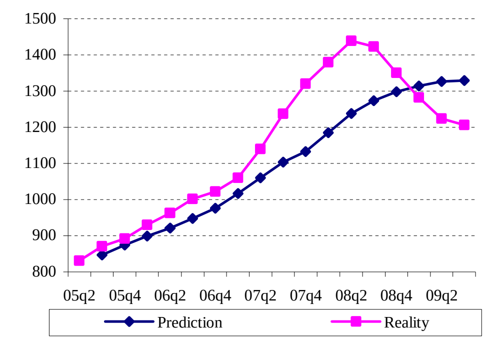
These three evaluations in general provide a satisfactory view of the future direction of the market, even with longer forecast horizons, as visible especially in the first chart in which the forecasts follows the actual values for almost two years, but also in the third chart, which depicts the future adjustment of the disequilibrium, even though at a somewhat slower rate. The level of correlation confirms that the growth rates are moving together visibly and that Theil coefficient again shows improvement compared with the “naive” forecast. On the other hand, however, some shortcomings are also evident, especially the inability of the forecast to capture the price explosion from the beginning of the second half of 2007 in the 1st and 2nd case. The model structure might be too simple to predict over- or undervaluation pressures building up and we might arguably need a much richer selection of tools and indicators for that purpose. That is also the reason for the less favourable results for MAPE in the 1st and 2nd case, Um in the 3rd case, and Uc in all cases. The forecast more or less tracks the estimated equilibrium price or, in the period from 2005 to 2006 (the 1st case) and 2008-2009 (the 3rd

[22] Instead of this point, it would be possible to select also 2007Q2 or 2007Q1. The results are very similar, however.

[23] Tables adjacent to the second and third chart in Chart 12 contain two types of information. The first row in each table evaluates the forecast for the period shown in the chart above the table. The second row for the purposes of creating the statistics groups together all n-step ahead forecasts starting at points 2005q3 – 2007q4 (and for the third table 2005Q3 – 2008Q2), where n is the number of forecast steps in the respective graph above the table.

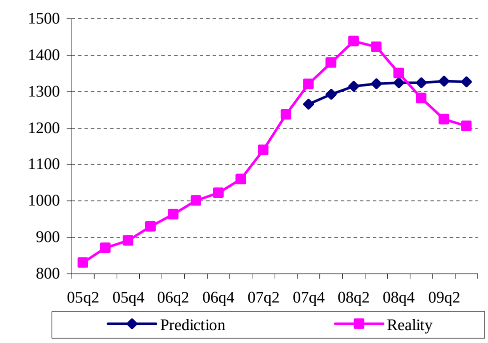
case) converges towards the equilibrium at a realistic pace[24]. The model B is examined in Chart 13.

Chart 13.1: Medium-term forecast 2005Q2, real prices (in EUR per m^2)



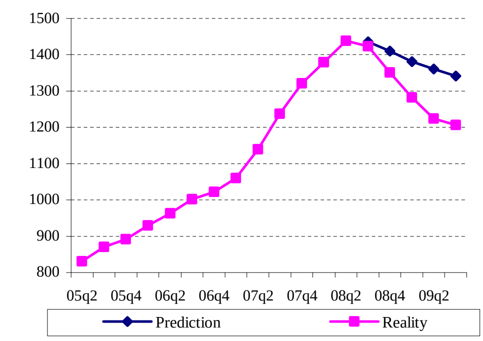
Corr	MAPE	Theil	Um	Us	Uc
0.70	5.54	0.69	0.003	0.66	0.34

Chart 13.2: Medium-term forecast 2007Q3, real prices (in EUR per m^2)



Corr	MAPE	Theil	Um	Us	Uc
0.95	5.50	0.78	0.01	0.94	0.04
0.69	6.25	0.62	0.11	0.55	0.33

Chart 13.3: Medium-term forecast 2008Q2, real prices (in EUR per m^2)



Corr	MAPE	Theil	Um	Us	Uc
0.84	3.66	0.40	0.41	0.38	0.21
0.80	4.62	0.57	0.16	0.40	0.44

Overall, model B achieved at first glance somewhat less precise forecasts, even though the comparison of the evaluation statistics is not capable of identifying clearly if it is true in all cases. In spite of the fact that the 1st case is comparable with model A, in the 2nd and 3rd case a pro-growth influence of the credit indicator is visible. At this moment it can thus be observed that model B achieved slightly weaker results, but the success rate of the models can change in the future.

8. Conclusion

The ECM model described in this article can indicate likely overvaluation and undervaluation, establish current and future equilibrium prices and on the basis of this information, identify the anticipated direction and extent of the future movement of real estate prices. The applied approach could more suitably depict the impact of individual determinants when compared to traditional econometric analysis. However, possible uncertainty and randomness regarding the selected parameters, future determinant values and the model structure also require expert assessment of market developments and further testing of the given model, which is currently being used as additional work aid. When it comes to the evaluation of model forecasts, it is evident that the "one step ahead" forecasts do not differ substantially from actual observations. Longer-term forecasts in general capture the future price trend. However they are not able to predict some important fluctuations. In the future it will be important to monitor the forecast precision, and to apply new forecasting methods as the number of observations increases.

Table 5: Summary results of the model forecast

MODEL A	Nominal price	% change y-o-y	% change q-o-q	MODEL B	Nominal price	% change y-o-y	% change q-o-q
2009Q4	1330	-10.1	0.6	2009Q4	1350	-8.7	2.2
2009 average	**1352**	**-10.5**	**-2.6**	**2009 average**	**1357**	**-10.1**	**-2.2**

[24] Due to the clarity of Charts 12 and 13, the equilibrium price curve was removed. It is, however, included in charts 1 and 6. The distinction between nominal and real quantities in this case is not substantial.

Table 5: Summary results of the model forecast

MODEL A	Nominal price	% change y-o-y	% change q-o-q	MODEL B	Nominal price	% change y-o-y	% change q-o-q
2010Q1	1356	-4.0	2.0	2010Q1	1404	-0.6	4.0
2010Q2	1388	3.4	2.4	2010Q2	1465	9.2	4.3
2010Q3	1433	8.4	3.3	2010Q3	1537	16.2	4.9
2010Q4	1486	11.7	3.7	2010Q4	1612	19.4	4.9
2010 average	**1416**	**4.9**	**2.8**	**2010 average**	**1505**	**11.0**	**4.5**
2011Q1	1553	14.5	4.5	2011Q1	1700	21.0	5.4
2011Q2	1609	15.9	3.6	2011Q2	1772	21.0	4.3
2011Q3	1660	15.8	3.2	2011Q3	1839	19.6	3.7
2011Q4	1708	14.9	2.9	2011Q4	1899	17.8	3.3
2011 average	**1632**	**15.3**	**3.5**	**2011 average**	**1802**	**19.9**	**4.2**
Change of average 2009 (%)	-	-10.6	-	Change of average 2009 (%)	-	-10.2	-
Change of average 2010 (%)	-	4.7	-	Change of average 2010 (%)	-	10.9	-
Change of average 2011 (%)	-	15.3	-	Change of average 2011 (%)	-	19.8	-

Appendix A – coefficient summary

Table A.1				
Variable	Source	Coefficient	Selected	Comment
Equilibrium coefficients ↓				
ry			1	It is a logical relationship, which could hold in the case of Slovakia as well. The OECD study uses a short sample, which was moreover obtained in a period of strong house price growth and economic growth, which could have biased the result upwards.
	OECD study of Slovakia	2.70		
	Hall (UK) 1968-1994	3.05		
	Holly (UK) 1939 - 1994	1		
	HMT, BoE (UK), Financial stability report 08 (NBS)	1		They assume that elasticity of 1 represents a general relationship between income and prices.
	Egert (CEE countries) 1993-2005	1		
	Kiss, Vadas (2005)	1		
	ECB (2003)	1		
	IMF (World Economic Outlook 2004)	Approx. 1		
	Egert (OECD) 1971-2005	0.45		
	IMF review (OECD countries) - average (WP/08/247)	2.22		
R			-0.01	Originally -0.036 - calculated as an approximate arithmetic average from the IMF review, mainly because their research includes a large number of various studies. However, the equilibrium price contributions of *R* would then be too large.
	Hall (UK) 1968-1994	-0.02		
	OECD study of Slovakia	-0.017		The paper reports *R* elasticity multiplied by 100. This is the result of using a different format of interest rate (e.g. 0.025 instead of 2.5%).
	Egert (CEE countries) 1993-2005	-0.01		
	Egert (OECD) 1971-2005	-0.01		
	IMF review (OECD countries) - average (WP/08/247)	-0.036		Elasticity reporting same as OECD.
h			-0.5	The OECD result is too large. Therefore, we then chose an estimate closer to the UK study and also to the IMF review, i.e. -2. However, this coefficient was still too strong and pulled the equilibrium price downwards in the long run. Therefore the value -0.5 was chosen, so that the resulting equilibrium price is not too distant from the observed prices and does not exhibit a downward trend.
	Hall (UK) 1968-1994	-2.3		
	OECD study of Slovakia	-17		Housing supply in this publication is expressed as a ratio of supply to population.

Table A.1				
Variable	Source	Coefficient	Selected	Comment
	IMF review (OECD countries) - average (WP/08/247)	-2.4		
pop			4.45	Most studies point to a strong relationship between population and house prices. The result by Egert and Mohaljek estimated for OECD countries looks sensible (-4.45). Stronger coefficients would cause an almost perfect comovement between equilibrium prices and population. (N.B. This study does not include Slovakia among the central and eastern Europe countries, but neither among OECD countries).
	Holly (UK) 1939 - 1994	1.45		But *pop* was expressed as a ratio of younger population to population overall. This might not be correct, since we could imagine a situation, where total population is growing faster than young population. Then this indicator would exhibit a downward pressure on price, even if the number of most likely buyers is increasing.
	OECD study of Slovakia	18.53		Again expressed as the ratio of young to total.
	Egert (CEE countries) 1993-2005	12.5		
	Egert (OECD) 1971-2005	4.45		
	IMF review (OECD countries) - average (WP/08/247)	8.25		
l/y			0.24	
	Holly (UK) 1939 - 1994	0.36		
	Egert (CEE countries) 1993-2005	0.24		
	MMF (WP/08/247)	1.3		The IMF review only includes one study with this indicator's influence estimated (Ireland). This only uses real credit as a determinant, rather than the *l/y* ratio.
Short-run coefficients ↓				
α_1 (error correction term)			-0.2	Egert, Mihaljek suggest that the correction is faster in CEE than in OECD in general. Therefore, the value -0.15 might be too low. On the other hand, most studies presented also provide coefficients lower than -0.26.
	Lecat (OECD countries) 1971-2003	-0.15		
	Holly (UK) 1939 - 1994	-0.11		
	Hall (UK) 1968-1994	-0.1		
	Egert (CEE countries) 1993-2005	-0.26		
	Egert (OECD) 1971-2005	-0.07		
dry			0.5	On the basis of the OECD results.
	Holly (UK) 1939 - 1994	0.7		
	Lecat (OECD countries) 1971-2003	0.5		
drhp(t-1)			0.44	Equal to the average of the OECD and IMF studies' results.
	Lecat (OECD countries) 1971-2003	0.35		

Table A.1				
Variable	Source	Coefficient	Selected	Comment
	IMF (World Economic Outlook 2004)	0.52		
	Holly (UK)	0.6 - 0.7		

Appendix B – additional estimation results

Table B.1: COINTEGRATION TEST (residual stationarity test for OLS model – no trend)			
Null Hypothesis: RESID has a unit root			
Exogenous: None			
Lag Length: 0 (Automatic based on SIC, MAXLAG=3)			
Augmented Dickey-Fuller test statistic			-4.237411
Test critical values:	1% level		-6.8347**
	5% level		-5.6905**
	10% level		-5.1686**
** MacKinnon (2010)			

Since the test statistic is larger than all the critical values, we can not reject the null hypothesis of non-stationarity in the residuals.

Table B.2: model ECM				
Dependent Variable: DLOG(RHP)				
Method: Least Squares				
Sample (adjusted): 2005Q3 2009Q3				
Included observations: 17 after adjustments				
	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.032	0.021	-1.559	0.1449
Error Correction*	0.262	0.541	0.485	0.6367
DLOG(RY)	1.282	0.646	1.985	0.0705
DLOG(LY)	0.624	0.403	1.550	0.1471
DLOG(RHP(-1))	0.560	0.211	2.654	0.0210
R-squared	0.736	Mean dependent var		0.022
Adjusted R-squared	0.648	S.D. dependent var		0.042
F-statistic	8.357	Durbin-Watson		1.801
Prob(F-statistic)	0.002			

*Error correction = LOG(*RHP*)+1.15326994524-1.7694988783*LOG(*RY*)+0.0555406316836*IR_REAL+ +1.3426536348*LOG(B_SUM_SA)-1.03572101868*LOG(*POP*)-0.66420304258*LOG(LY)

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