SHORT AND LONG RUN BEHAVIOUR OF HOUSE PRICES IN EASTERN EUROPEAN COUNTRIES: A COMPARATIVE APPROACH

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This paper uses cointegration and error correction models in order to examine the long run and short run behaviour of house prices in Eastern European countries, which is then compared to developed EU countries. Four transition (Bulgaria, Croatia, the Czech Republic, and Estonia) and three developed countries (Ireland, Spain, and the U.K.) are included in the sample. House prices behaviour for each country is modelled separately as a function of income, interest rates, credit, construction activity, employment and house price persistence. The results of the empirical exercise suggest that house prices, income and house price persistence explain house price changes in the majority of the countries. In half of the countries construction output also explains house price variance, but the magnitude of construction output coefficients is rather small. In the short run house prices are not weakly exogenous, but adjustment coefficients are quite small and sometimes lagged, probably due to the presence of house price persistence.

Key words: house prices, cointegration, error correction, transition
JEL classification: C22, R21, R31

1. INTRODUCTION[1]

House prices and their links to the macroeconomy in developed countries have been a subject of increasing body of empirical work. In the last few years the interest for housing market research intensified due to the role housing markets played in recent global economic crisis. Namely, recent boom in house prices in many developed countries and the following sharp busts in some of them has attracted policymakers‘ and researchers‘ attention since it has become apparent that housing influences the business cycle. However, the boom-bust cycle in house prices is not idiosyncratic to developed countries since similar or even more pronounced house price developments were observed in the countries of the former Soviet Union, in Easter Europe, Middle East, North Africa, and Central Asia region (Beidas-Strom et al, 2009; Posedel and Vizek, 2009; Vahram et al, 2010).

However, to the best of our knowledge, there are only several papers that analyze house price determinants from country–by–country or cross–country perspective in emerging economies in general, and in Easter European countries in particular. Studies that compare house price behavior in these countries to developed countries are even scarcer. Hence the aim of this paper is to fill this gap in the literature by conducting a country–by–country analysis with comparison of results across countries in order to answer the following questions: What are the most important house price drivers in Eastern European countries? How does house price behavior in the short run differs to long run behavior? What are the key similarities and differences between Easter European and developed European Union countries when it comes to house price drivers?

In order to obtain answers to the research questions, this paper uses Johansen cointegration and error correction models. Finite sample corrections of cointegration trace and max statistics are applied due to small sample size of Eastern European countries data set. General-to-specific procedure is applied in order to obtain specific error correction models of house prices for each individual country. All together seven countries are included in the sample; four transition countries (Bulgaria, Croatia, the Czech Republic, and Estonia) and three developed EU countries (Ireland, Spain, and the U.K.). Data range differs somewhat across countries, which is a consequence of the availability of house price series. Data span for transition countries is somewhat shorter when compared to developed countries; i.e. the starting observation for Croatia is the fourth quarter of 1996, for Estonia it is the first quarter of 1997, and for Bulgaria and the Czech Republic it is the first quarter of 1998.

The remainder of the paper is organized as follows. Section 2 is a review of the literature on house price modeling in transition countries of Central and Eastern Europe. Section 3 is a presentation of the data and the applied methodology and includes a detailed discussion of the results of the empirical analysis. Section 4 concludes the paper.

2. LITERATURE REVIEW

House price dynamics in developed countries have been in research focus for the last couple of decades. However, this growing body of literature does not offer a unifying explanation for house price cycles. Hence Leung (2004: 255) in his survey of housing and macroeconomy nexus concludes that existing research has not provided adequate explanations for the dynamics of the housing market.

Unlike developed countries, house prices in European transition countries are far less explored. To the best of our knowledge, there are only several published papers which explore house price determinants in transition countries. Often, the largest impediment for such an analysis is the lack of reliable data on house prices. Studies that employ a comparative cross-country perspective are even more scarce. Given the fact that in some transition countries like Bulgaria and Estonia house price boom and bust has been more pronounced when compared to developed countries which underwent the most extreme boom and bust cycles, more empirical studies are needed in order to understand the link between house prices and macroeconomy in transition countries.

First empirical study of house prices in transition European countries was done by Egert and Mihaljek (Egert and Mihaljek, 2007). The authors estimated four-variate panels composed of eight transition and 19 developed OECD economies. Given the limited data availability, their modelling strategy consisted of reserving two explanatory panel variables for various proxies of income and interest rates while the third explanatory variable was varied. The results of the empirical exercise indicated the GDP and interest rates as the most important house prices drivers, with their elasticities with respect to house prices being higher for transition countries which exhibited a more intensive house price increase. The results of the analysis also suggested that growth of credit, population changes, and changes in construction costs also drive changes in house prices, but to a lesser degree when compared to the GDP and interest rates.

Contrary to Egert and Mihaljek (2007), Posedel and Vizek (2009) concluded that house price persistence is the most important factor in explaining the house price variance. They applied the SVAR and multiple regression models and analyzed house price determinants in three EU-15 countries and three Eastern European countries. Besides house price persistence which prevails in Croatia, Ireland, Poland, and Spain, in the U.K. and Estonia interest rates explain the biggest portion of the house price variance. Moreover, house prices in three EU-15 countries explained a significant fraction of the GDP, construction activity, and interest rates variance, while this is not the case for Eastern European countries. In both group of countries supply side factors do not determine house prices in the short-run.

Stepanyan et al (2010) used panel data approach in order to model house price behavior in former Soviet Union countries (FSU countries). Their analysis also included all three Baltic countries. Given the fact that most of the FSU economies depend heavily on remittances and other types of capital inflows, the authors used these two variables in house price model along with other standard explanatory variables. The results of the study suggest real GDP, remittances, and foreign inflows have been significant drivers of house prices in the FSU countries. Moreover, the analysis indicated house prices adjust quickly the discrepancies from the long-run equilibrium. Finally, the authors established that the average misalignment of house prices in the FSU countries was in the range of 14 to 23 percent in the aftermath of the global financial crisis.

Posedel and Vizek (2010) used a nonlinear framework in order to detect house price determinants and adjustment properties. They tested for threshold cointegration using a sample of four developed countries including the U.S.A., and four Eastern European countries. They showed that the house prices adjustment process in transition countries and the U.S.A. is asymmetric. Contrary to Stepanyan et al (2010) findings, Posedel and Vizek showed that house price adjustment parameters are quite small if modeled within an asymmetric error correction framework. Granger causality tests indicate that in Bulgaria, the Czech Republic, Estonia, and the U.S., house price persistence is responsible for slow adjustment of house prices to disequilibria. Moreover changes in GDP Granger cause house price changes in Estonia and the U.S.; while interest rate changes Granger cause house prices

in Bulgaria, Croatia, and the U.S. The authors conclude that house prices were not completely detached from fundamentals in analyzed countries. However, the emergence of the house price boom was supported by house price persistence coupled with a slow and asymmetric adjustment process.
Zemčík (2009) focuses on the relationship between house prices and rents in the Czech Republic in order to establish whether there was a bubble in the Czech housing market. The results of the panel data models suggest that housing in the Czech Republic was somewhat overpriced. However, the degree of overpricing seems small, which in turn means that a large house price correction is not expected. Finally, the author shows that house prices are aligned with the fundamentals because the changes in rents in the capital city predicted changes in prices and vice versa.
Hlavacek and Komarek (2009) look at fundamentals of the house prices in the Czech Republic. Using regression and panel data models they confirmed the importance of unemployment rate, wages and credits for house price developments. The demographic factors, net migration and divorce rate, also explain a part of house price variance in the Czech Republic.

3. DATA AND METHODOLOGY

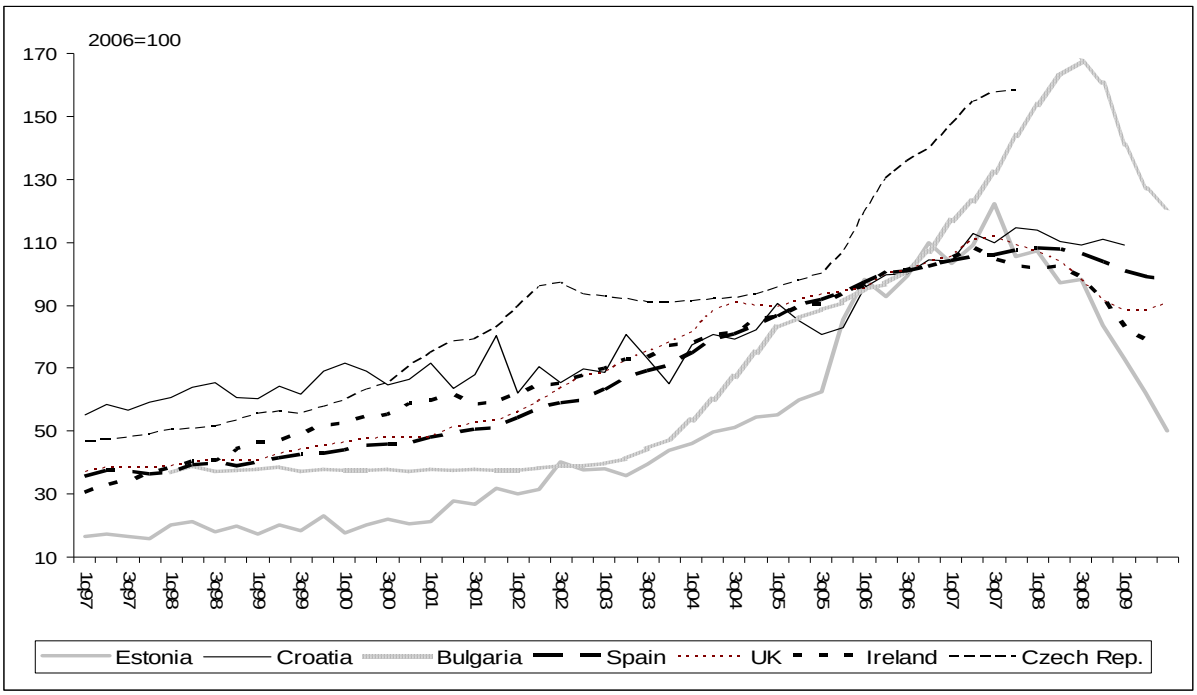
3.1. DATA

In this section we briefly describe the applied methodology and the data. As stated earlier the sample includes three developed EU countries; Ireland, Spain, and the U.K., and four transition Eastern European countries: Bulgaria, Croatia, the Czech Republic, and Estonia. The Eastern European countries included in the sample are the only countries for which it was possible to obtain longer house price series. The availability of house price series also conditioned the data span which differs across countries. Data for developed countries starts from the first quarter of 1995. The last observation available for Ireland is the first quarter of 2009. For other three countries data extend to the second quarter of 2009. Due to the fact that house price data for the U.K. are available further back into the past, we estimated cointegration and error correction model for the U.K. on shorter and longer sample. Longer sample consists of annual data available from 1969.

Data span for transition countries is somewhat shorter due to well-known transition factors. The longest sample is available for Croatia, as it starts with the observation for the fourth quarter of 1996. Data for Estonia range from the first quarter of 1997, while for Bulgaria and the Czech Republic the starting observation is the first quarter of 1998. Series for all transition countries end in the second quarter of 2009, except for the Czech Republic where house price data are available until the fourth quarter of 2008. Aside from the house price series, the data set for each country is comprised of quarterly series for the real GDP, the interest rate on a housing loan, total housing loans, employment, and construction activity.
Series expressed in nominal terms, i.e. house prices, interest rates, and housing loans, were deflated using the consumer price index. All series except interest rates were transformed into logarithms. All series were tested for unit roots using the Ng-Perron test (Perron and Ng, 1996). The results suggest that all series are stationary in first differences. One must, however, note that housing loans series appear to be very persistent I(1) processes which on occasion leads to inconclusive unit root test results. Due to space considerations, the results of the unit root test are not presented in this paper, but can be obtained upon request from the authors. More details on all the series are available in Appendix.

Figure 1 displays nominal house prices for Croatia, Bulgaria, Estonia, the Czech Republic, Ireland, Spain, and the United Kingdom from the first quarter of 1997 to the second quarter of 2009. All countries had experienced substantial increases in house prices. However, during 2007 and 2008, the price trend reversed and countries that witnessed the most pronounced house price boom are now seeing their house price searching for a bottom. The figure also shows that two transition countries (Estonia and Bulgaria) exhibit the most intensive house price appreciation. Although some similarities in house price cycles across countries exist, one can only speculate that all countries share a similar house price trend. One would need at least another decade of data before we can be certain that house price comovement indeed exist.

Figure 1. Nominal house price developments



Source: various sources, for details consult the Appendix.

In order to get a better grasp of the intensity of house price appreciation and subsequent correction in Table 1 cumulative increases and decreases of house prices are displayed. One can notice that there are substantial differences in both cumulative house price appreciation and the correction that followed afterwards. The highest house price increase is recorded in Estonia and Bulgaria prices rose by 631 and 336 percent respectively in approximately eleven years. On the other hand, house price increase in the Czech Republic seems in line with developed countries that experienced house price boom, while house price increase in Croatia seems quite modest comparatively speaking. As against Easter European countries, house price inflation in EU-15 countries seems to have followed more similar path. In all three EU-15 countries the prices have tripled in approximately eleven years.

As far as house price deflation is concerned, the biggest cumulative drop is so far recorded in Estonia and Bulgaria, which seems logical given the fact that in those two countries house prices appreciated the most.

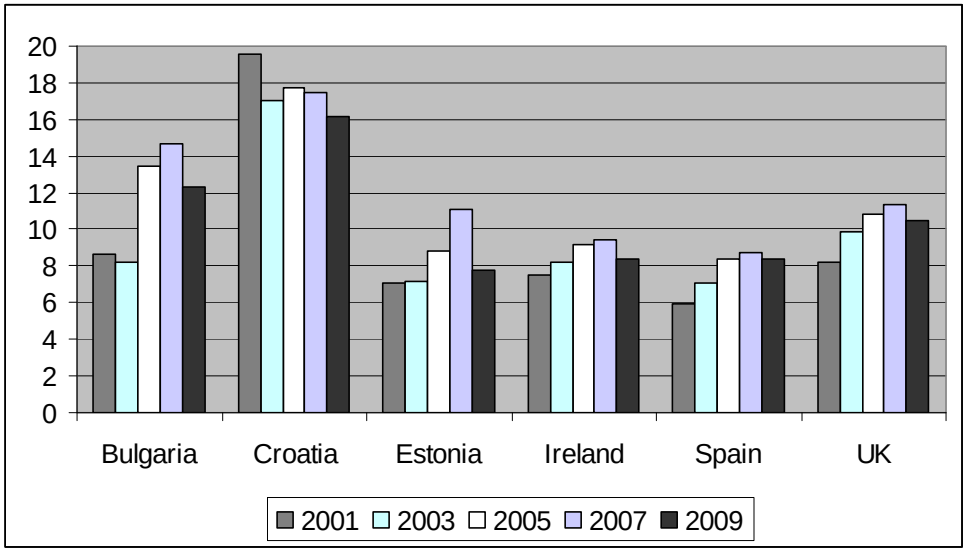
Table 1. Nominal house price appreciation and subsequent correction

	Estonia	Czech Rep.	Croatia	Bulgaria	Spain	the UK	Ireland
Kumulative appreciation	630.8	237.9	107.3	335.7	204.1	201.6	255.6
Kumulative correction	-58.0	-	-14.0	-28.0	-10.0	-21.0	-27.0

Source: various sources, for details consult the Appendix.

Before turning to the empirical analysis, it is useful to take a look at housing affordability indices. OECD (2005) suggests that housing affordability indices can be used as indicators of over - or under - valuation of housing, under the condition that these indicators are available for the longer time period.[1] In Figure 2 we present housing affordability indices for the analysed countries. The Czech Republic could not be included in the analysis because it has no house price data available in levels. The affordability indices are calculated according to so called "shelter first approach" (Robinson, Scobie and Hallinan, 2006) which assumes that outlays for housing are reimbursed first, while the residual part of the income is used for other types of consumption and/or savings. As a measure of income we used GDP per capita in EUR, while house price is represented by the price of a square meter of housing (also expressed in EUR). One interprets affordability index in the following fashion: the higher is the value of the index, the lower is housing affordability. Moreover, if the value of the index is higher that its long run average, it might indicate that house prices are over valuated.

Figure 2. Housing affordability indices



Source: various sources, for details consult the Appendix.

When one observes Figure 2, it becomes apparent that during the peak years the affordability of housing was lower in all three Eastern European countries when compared to EU-15 countries, even though house price level transition countries is significantly higher. This might suggest that house prices in all Eastern European countries should be more prone to

[1] For the same purpose one could analyse price to rent ratios, but unfortunately the data on rents in three out of four transition countries are not available.

additional downward adjustment in the future. However, in order to substantiate such conclusion, one would require much longer series of affordability indices. When observing each country individually, one can conclude that the affordability of housing across time decreased the most in Estonia and Bulgaria – two countries that have experienced the most pronounced run-up of house prices. Moreover, affordability improved in all countries during 2009, as a result of house price correction.

3.2. METHODOLOGY

The cointegration approach to the analysis of asset price series was first introduced by Campbell and Shiller (1987), who tested the present value model for bonds and stocks using cointegration. Following them, Hall et al. (1997), Hort (1998), Malpezzi (1999), Wang (2000), Meen (2002), Gallin (2006), Pagés and Maza (2003), McQuinn and O'Reilly (2008), and Mikhed and Zemčík (2009) applied cointegration in order to model house prices in developed countries. To the best of our knowledge, there are no cointegration studies for house prices in emerging Eastern European countries.

To determine whether the house prices in the long run form an equilibrium relationship with macroeconomic fundamentals Johansen procedure, i.e. Trace and Max statistics tests are used. These two tests statistics also determine the number of cointegrating vectors between variables (Johansen, 1988; Johansen, 1991). Trace statistic tests the hypothesis that the number of cointegrating vectors is less than c while the max statistic tests that the number of cointegrating vectors is equal to c against c + 1. Since Johansen's tests are biased when the constant term is included in the model and tend to detect cointegration more often then asymptotic theory would suggests (Cheung and Lai, 1993), Ahn and Reinsel (1990) and Reimers (1992) suggests a finite sample correction which is particularly useful in small samples and when larger number of variables are included in the analysis. Finite sample correction takes into account the number of parameters and degrees of freedom. Adjusted test statistics are denoted by Trace test (T-nm) and Max test (T-nm). Since corrected Trace and Max test statistics can indicate different number of cointegrating vectors when compared to their asymptotic, the final decision on the number of vectors is based on corrected test statistics.

Cointegration analysis is started by estimating VAR in form of Equation 1 for each country, where *k* represents country, and $Y_{k,t}$ an (6x1) vector containing the values that six variables assume at time *t.* $Y_{k,t}$ consists of six variables representing demand side of the housing market, supply side of the housing market and the financing conditions; namely real house price, real GDP, employment, real volume of housing loans, real interest rate on housing loan and construction output index.

$$\mathbf{Y_{k,t}}=\mathbf{c_k} + \sum_{j=1}^{p} \Phi_{k,j}\, \mathbf{Y_{k,t-p}}+\boldsymbol{\varepsilon}_{\mathbf{k,t}} \qquad (1)$$

The dynamics of $Y_{k,t}$ are presumed to be governed by a p^{th}-order Gaussian vector autoregression, where p >0 represents the lag length, the (6x1) vector contains the constant terms of the VAR, the matrices $\Phi_{k,1}$, …, $\Phi_{k,p}$ contain the autoregressive coefficients while $\varepsilon_{k,t}$ ~ i.i.d. N(0, Σ).

In the case no cointegration vector was found, we reduced VAR by one variable – employment. If still no cointegration vector was detected, we continued the analysis by excluding housing loans. In the case that remaining four variables do not form a long run

relationship, we excluded construction output index from VAR, leaving just three variables: real house price, real GDP and real interest rate on housing loan. These three variables are the most often used variables in this kind of empirical exercises. Moreover, these variables were the base variables Egert and Mihaljek (2007) used in their analysis of house price determinants in Central and Easter European countries. We feel that it is appropriate to exclude employment and housing loans from the analysis in the case no cointegration was found since remaining variables partially represent the excluded variables (GDP can be thought of as a proxy for employment, while interest rate on housing loans represents well the availability of financing). In this fashion we obtained cointegration vectors for all countries.

After we derived the long run relationships, we estimated an error correction model of house prices for each country. Thereby we followed a general-to-specific approach. At the beginning, we estimated a general unrestricted model (Equation 2) in which we regressed first difference in logarithm of real house prices (Δhp_t) on error correction term (Δect_{t-i}) and first difference in logarithm of the GDP (Δgdp_t), employment (Δemp_t), housing loans (Δhl_{t-i}), interest rate (Δir_{t-i}), and construction output (Δco_{t-i}). Moreover, we also included lagged values of dependant variable (Δhp_{t-i}) in the estimation in order to control for house price persistence.

$$\Delta hp_t = c + \sum_{i=1}^{4} \Delta ect_{t-i} + \sum_{i=1}^{4} \Delta hp_{t-i} + \sum_{i=1}^{4} \Delta gdp_{t-i} + \sum_{i=1}^{4} \Delta ir_{t-i} + \sum_{i=1}^{4} \Delta emp_{t-i} + \sum_{i=1}^{4} \Delta hl_{t-i} + \sum_{i=1}^{4} \Delta co_{t-i} + \varepsilon_t \qquad (2)$$

All other independent variables, including error correction term, entered into general unrestricted model with four lags. We feel that it is appropriate to include lagged error correction terms in the general unrestricted model since one can expect that fundamentals take a longer time to kick in if house price persistence is present. Than the next step was to eliminate statistically insignificant terms from the model which led to the derivation of the final error correction model, which had to satisfy all standard diagnostic tests.

3.3. RESULTS

Finite sample corrections of Trace and Max statistics suggested that in the case of all countries, except Ireland, one cointegrating vector can be found, which enabled us to directly determine long run parameters. The details on trace and max statistics, along with the long run parameters and adjustment coefficients, its standard errors and associated tests can be found in Tables 1 to 8a displayed in Appendix. In case of Ireland two vectors were found, which necessitated the joint imposition of at least four restrictions on cointegrating space in order to identify the long run parameters. These restrictions and corresponding coefficients are presented in Table 7a.

Table 2 displays the long run elasticities of house prices with respect to other variables. This Table also indicates which variables were used in order to obtain a cointegrating relationship. One can notice that in the case of Croatia, Bulgaria, the U.K., and Spain house prices only seem to form a relationship with GDP (which proxies both the income and overall economic activity) and interest rates (which represents the financing conditions and it also partially represents a monetary policy stance). In Estonia house prices also react to changes in the construction activity, while in Ireland and the Czech Republic they react both to changes in the construction activity and housing loans.

One can observe from the Table that GDP and interest rates seem to matter the most for house prices in the long run. In that respect the results of this analysis are similar to the conclusions reached by Sutton (2002), Meen (2002), Abelson et al. (2005), Pages and Maza (2007) and McQuinn and O'Reilly (2008) about the importance of interest rates and income as determinants of house price. As far as the long run elasticities of house prices to GDP are concerned, we can notice that it varies from 0.04 percent in the case of Croatia to 2.97 percent in the case of the U.K. (1995 sample). There seem to be no differences between two main group of countries (developed and CEEC) with respect to the magnitude of elasticities.
On the other hand, long run elasticities of house prices to changes in interest rates are quite high in all countries except Ireland and range from 2.1 percent in the case of Croatia to 4.0 percent in the case of Estonia. Once again there are no apparent differences between two main group of countries when the size of the elasticity is considered. The interest rate elasticity in the case of Ireland is somewhat smaller (1.1 percent), but one must note that Ireland is the only country in which house prices are also elastic to the other variable representing the financing conditions - housing loans.
In three out of seven countries house prices seem to be elastic in the long run to the changes in the supply of new housing units. However, the value of these elasticities is lower than 1 in absolute terms. One must note that if we were to use housing stock variable instead of construction output index, housing supply might have had a more important role in forming house prices in the long run. Unfortunately, housing stock series for CEE countries are not available, so we are not in a position to test this assumption.

Table 2. Long run elasticities of house prices

Variables	Bulgaria	Croatia	the Czech Rep.	Estonia	Ireland	Spain	the U.K. (1995)	the U.K. (1969)
	β coefficients							
House price	1.00	1.000	1.000	1.000	1.00	1.00	1.000	1.000
Constant	-	2.937	3.800	-	-	1.027	-11.53	0.233
GDP	0.591	0.037	0.749	1.835	0.781	1.076	2.97	1.364
Employment	-	-	-	-	-	-	-	-
Construction	-	-	-0.238	-0.385	-0.781	-	-	-
Housing loans	-	-	-0.266	-	0.674	-	-	-
Interest rate (housing loan)	-2.8	-2.1	-0.09	-4.0	-1.1	-3.22	-2.9	-0.1

Source: Calculation of the author.

What one can takes from this analysis is that house prices seem to react the most to changes in financing conditions, which can help explain why house prices experienced substantial increase during 1990ies and in the first half of this decade. House prices also react in the long run to changes in economic activity and income, but in all countries the size of house price elasticity with respect to GDP is smaller when compared to the interest rate elasticity (with exeptions of the Czech Republic and the U.K. (1969 sample).

Table 3. Error correction model – summery of estimation results

Explanatory variables	Bulgaria	Croatia	the Czech Republic	Estonia	Ireland	Spain	the U.K. (1995)	the U.K. (1969)
Error correction term	0.45** (1) -0.46** (2)	-0.53**(4)	-0.09**(2)	0.10 (1)	-0.38* (1)	-0.03* (1)	0.16** (3)	-0.29* (3)
House price persistence	-0.42* (4)	-0.68* (1) -0.86* (2) -0.70* (3)	0.73* (1)	-0.42* (1) -0.28**(2)	-	0.58* (1) 0.36* (3)	0.55* (1) -0.35**(4)	-0.20**(2)
GDP	1.06** (1) 1.36** (4)	1.28* (1)	1.11**(3)	2.27* (1)	0.26** (2)	0.41** (1)	1.26** (1)	1.63*(1)
Interest rate	-1.71* (1)	-1.31**(2) 1.41* (3)	0.25**(4)	-	-0.4** (4)	-	-0.97**(4)	-0.30**(4)
Housing loans	0.48* (1)	0.47** (3)	-	0.79** (2)	-	-	-	-
Employment	-	5.09* (2)	-	-	-	-	-	1.12**(3)
Construction output	-	-0.81* (2)	-	-0.72* (3)	-0.22* (1)	-0.10* (1) -0.09* (2)	-	0.24**(1)
$R(adj)^2$	0.76	0.59	0.67	0.54	0.71	0.76	0.49	0.63
RSS	0.0033	0.018	0.0019	0.049	0.002	0.0006	0.0095	0.013
AR test	0.38 [0.82]	2.11 [0.12]	0.342 [0.79]	0.11 [0.97]	0.55 [0.70]	0.75 [0.56]	0.56 [0.69]	1.45 [0.25]
ARCH test	1.07 [0.39]	0.42 [0.79]	0.53 [0.66]	0.85 [0.50]	0.53 [0.71]	1.99 [0.12]	1.68 [0.17]	0.923 [0.35]
Normality test	1.72 [0.42]	0.67 [0.71]	4.04 [0.13]	0.93 [0.62]	0.73 [0.65]	3.01 [0.22]	0.23 [0.89]	0.267 [0.87]
RESET test	1.35 [0.25]	0.77 [0.39]	0.078 [0.78]	0.097 [0.76]	0.33 [0.57]	0.83 [0.37]	0.21 [0.65]	2.74 [0.11]

Note: * - significant at 1 percent; ** - significant at 5 percent; number in parenthesis represent time lag; number in brackets represents p-value.
Source: Calculation of the author.

It is also worth comparing the results for the U.K. for the longer (1969) and shorter (1995) sample. Corrected Trace and Max statistic suggested in both cases that cointegration exists between house prices, real GDP and the interest rates. However, income and interest rate elasticities in the model estimated on sample dating back to 1969 are much smaller in magnitude when compared to model estimated on data starting in 1995. The difference is particularly pronounced with the interest rate elasticity which increased from 0.1 recorded on longer data series to 2.9 recorded on shorter series. This example goes to show how the impact of financial sector developments on housing market has increased over time.

Table 3 summarizes the results of error correction models. As one can notice, country models satisfy all diagnostic tests. Further more, in all countries except Estonia house prices are not weakly exogenous, i.e. they respond to discrepancies from the long run equilibrium. However, the adjustment parameters are quite low for most of the countries, with the exception of Bulgaria and Croatia where house prices adjust about half of the discrepancies in the single quarter. Lagged values of house prices are significant in all countries except Ireland, suggesting that house price persistence is a widely spread phenomenon. Judging from the magnitude of lagged house price coefficients which range from 0.42 in Bulgaria to 0.86 in Croatia, house price persistence has a strong impact on house price developments. Further on,

error correction estimates for the two U.K. models suggest that house price persistence in that country has gained strength over time.

Besides house price persistence, error correction model results also reveal the importance of income as a house price determinant. Income is significant and correctly signed in all countries, with most of the its elasticities revolving around 1. Along with income, employment also seem to influence short run behavior of house prices in Croatia and the U.K. Interest rates are significant in all countries except Estonia and Spain, with their elasticities ranging from -0.3 in case of the U.K. (1969 sample) to -1.7 in case of Bulgaria. Instead of interest rates, in Estonia the other financial sector proxy - housing loans – determines the short run behavior of house prices. Housing loans are also significant in two other transition countries: Bulgaria and Croatia. Unlike transition countries, housing loans do not influence house prices in developed countries in the short run. Finally, supply side factors also seem to play an important role for the short run behavior of house prices. Thus an increase in construction output lowers house prices in Estonia, Croatia, Ireland, Spain and the U.K. One must however note that although in general lower than one in absolute terms, construction output elasticities are higher in transition countries when compared to developed countries.

When comparing two error correction models for the U.K., one reaches similar conclusions as with cointegration models for the U.K. Namely, the magnitude of the short run interest rate elasticity and house price persistence has increased over time. However, unlike cointegration models, error correction models suggest that the importance of income as a house price determinant has decreased somewhat over time.

4. CONCLUSION

The aim of this paper was to detect the most important house price determinants in Eastern European countries. By modelling both, the long and the short run house price determinants, we wanted to explore the key similarities and differences between Easter European and developed European Union countries.

The results of this study suggests that there are be no significant differences between transition and developed EU countries regarding the influence of income and interest rates on house prices in the short and long run. Namely, the results reveal that GDP and interest rates matter the most for house price behavior in the long run. Long run elasticities of house prices to GDP changes vary from 0.04 percent in the case of Croatia to 2.97 percent in the case of the U.K. (1995 sample), with no apparent differences between two main group of countries. Long run interest rates are quite high in all countries except Ireland and range from -2.1 percent in the case of Croatia to -4.0 percent in the case of Estonia. Ireland is the only country with more moderate interest rate elasticity, but Irish house prices are also elastic to the other financial variable - housing loans. In all countries except the Czech Republic, long run interest rate elasticities are in absolute terms higher than income elasticities, thus suggesting that interest rates had somewhat more important role for the housing markets in the last two decades. Error correction model estimates also suggest that income and interest rates determine the behavior of house prices. Income is significant and correctly signed in all countries, with most of the individual country elasticities revolving around 1. Interest rates are significant in all countries except Estonia and Spain, with their elasticities ranging from -0.3 in case of the U.K. (1969 sample) to -1.7 in case of Bulgaria.

Error correction model estimates also suggest that house prices in all countries except Estonia correct the discrepancies from the long run equilibrium. However, the adjustment parameters are quite low for most of the countries, with the exception of Bulgaria and Croatia where house prices adjust almost all discrepancies in two quarters. Smaller adjustment parameters can be a consequence of house price persistence which prevents fundamentals from correcting the discrepancies. House price persistence is significant and, if judging from the magnitude of lagged house price coefficients, rather strong in all countries except Ireland.
Construction output determines house prices in about half of the countries in the sample. In all cases the elasticity of house prices to construction output changes are below one. However, there are differences across two group of countries. In the short run these elasticities are higher in transition countries when compared to developed countries, while the opposite is true for the long run elasticities.

The results of cointegration and error correction models for the U.K. estimated on longer (1969) and shorter (1995) sample are also quite telling. Both types of models reveal that in the U.K. the influence of financial sector developments on housing market has increased over time. In other words, both short run and long run interest rate elasticities estimated on a sample dating back to 1995 are higher when compared to elasticities estimated on a sample dating back to 1969. Moreover, the comparison of two error correction models for the U.K. also suggests that the house price persistence has increased over time.

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APPENDIX
DATA DESCRIPTION AND SOURCES

Country: Croatia
Data range: 1996 Q4 – 2009 Q2

House price	Real Estate Exchange Database (Burza Nekretnina)	Average purchase-sale of all housing units (houses and apartments; old and used) consisting the database
Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction production index	Croatian Central Bureau of Statistics	Volume of construction works undertaken by legal entities with 25 or more employees, 2000=100
Number of employed persons	Croatian Central Bureau of Statistics	Total number of employed persons in legal entities, crafts and free lance activities, in 000
Housing loans	Croatian National Bank	Housing loans series is available July 1999, before July 1999 the series was reconstructed using growth rates of total loans to households, in millions EUR
Interest rate on housing loans	Croatian National Bank	Average annual interest rates to housing loans is available since January 2002, before 2002 average annual interest rate for long-term housing loans with currency clause series was mean adjusted and used
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices.

Country: Bulgaria
Data range: 1998 Q1 – 2009 Q2

House price	National Statistical Institute	Average market prices of homes, quarterly
Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction production index	Eurostat	Construction production index, 2005=100
Number of employed persons	Eurostat	Total employment – national concept, in 000
Housing loans	Bulgarian National Bank	Loans for house purchase, in 000 BGN
Interest rate on housing loans	Bulgarian National Bank	Average interest rate on EUR loan for house purchase
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices

Country: Estonia
Data range: 1997 Q1 – 2009 Q2

House price	Estonian Statistics http://www.stat.ee/real-estate	Average purchase-sale price per square meter of a two room and a kitchen dwellings of satisfactory condition in capital city (Tallin) intermediated by real estate agencies, in EUR. The series is highly correlated with average purchase-sale price series for entire Estonia which could not be used since it starts from 2002
Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction	Eurostat	Construction production index, 2005=100

production index		
Number of employed persons	Eurostat	Total employment – national concept, in 000
Housing loans	Bank of Estonia	Total housing loans, in millions EUR
Interest rate on housing loans	Bank of Estonia	Weighted average annual interest rate to housing loans granted to individuals
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices

Country: Czech Republic
Data range: 1998 Q1 – 2008 Q4

House price	Czech Statistical Office	Apartment price indices (2005=100)
Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction production index	Eurostat	Construction production index, 2005=100
Number of employed persons	Eurostat	Total employment – national concept, in 000
Housing loans	National Bank of Czech Republic	Lending to households for long-term house purchase, in millions EUR
Interest rate on housing loans	International Financial Statistics	Interest rate charged on loans to households
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices, 2000=100

Country: Spain
Data range: 1995 Q1 – 2009 Q2

House price	National Institute of Statistics	Average price pre square meter of a real, in EUR
Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction production index	Eurostat	Construction production index, 2005=100
Number of employed persons	Eurostat	Total employment – national concept, in 000
Housing loans	Bank of Spain	Total housing loans, in millions EUR
Interest rate on housing loans	Eurostat; Bank of Spain	For the period from 1995 Q1 – 2003 Q1 average annual interest rate on housing loans for households, from 2003 Q2 onwards average interest rate on housing loans over 5 years maturity, outstanding amount
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices, 2000=100

Country: United Kingdom
Data range: 1995 Q1 – 2009 Q2 and 1969 – 2008 (annual frequency)

House price	Department for Communities and Local Government www.communities.gov.uk/	Average sale prices of new and old house, in EUR

Gross domestic product	Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates)
Construction production index	Eurostat	Construction production index, 2005=100
Number of employed persons	Eurostat	Total employment – national concept, in 000
Housing loans	Bank of England	Total secured sterling lending to individuals and house associations, outstanding amount, in millions EUR
Interest rate on housing loans	Bank of England	Average standard variable mortgage rate to households
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices, 2000=100

Country: Ireland
Data range: 1995 Q1 – 2009 Q1

House price	Department for environment, heritage and local government www.environ.ie	Average national new house price, in EUR
Gross domestic product	Irish Statistical Office http://www.cso.ie/statistics/; Eurostat	Gross domestic product, millions of euro, chain-linked volumes, reference year 2000 (at 2000 exchange rates). The data for period 1995 Q1 – 1996 Q4 were reconstructed using quarterly growth rates of industrial production volume from Irish statistical office.
House completion index	Irish Statistical Office http://www.cso.ie/statistics/	Calculated using the quarterly series of house completion number in all local authorities, 2000=100
Number of employed persons	Irish Statistical Office http://www.cso.ie/statistics/	Persons aged 15 years and over in employment , in 000
Housing loans	Department for environment, heritage and local government www.environ.ie	Total housing loan payments, banks and building societies, in millions EUR
Interest rate on housing loans	Department for environment, heritage and local government www.environ.ie	Average annual building society mortgage interest rate
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices, 2000=100

ESTIMATION RESULTS

Table 1. Johansen cointegration: Croatia

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	41.54 [0.008]	25.46 [0.015]	39.00 [0.017]	23.90 [0.027]
1	0.405	16.08 [0.174]	11.07 [0.255]	15.09 [0.226]	10.39 [0.311]
2	0.202	5.01 [0.293]	5.01 [0.292]	4.70 [0.329]	4.70 [0.328]
3	0.097	-	-	-	-

Note: p-values in brackets; VAR includes 1 lag and a restricted constant. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests except normality.
Source: Calculation of the author.

Table 1a. Johansen cointegration: Croatia

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.000	0.00	-0.377	0.113
Constant	-2.937	0.622	-	-
GDP	-0.037	0.158	0.100	0.0391
Interest rate on a housing loan	0.021	0.0048	-9.007	3.108

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 2. Johansen cointegration: Czech Republic

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	102.6 [0.000]	43.52 [0.002]	77.01[0.048]	32.64 [0.087]
1	0.66	59.16 [0.015]	30.25 [0.027]	44.37 [0.277]	22.68 [0.245]
2	0.53	28.91 [0.205	14.24 [0.454]	21.68 [0.619]	10.68 [0.777]
3	0.299	14.68 [0.251]	10.57 [0.295]	11.01 [0.549]	7.93 [0.566]
4	0.2322	4.10 [0.409]	4.10 [0.408]	3.08 [0.575]	3.08 [0.574]
5	0.097	-	-	-	-

Note: p-values in brackets; VAR includes 2 lags and a restricted constant. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests except normality.
Source: Calculation of the author.

Table 2a. Johansen cointegration: the Czech Republic

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.000	0.00	-0.087	0.030
Constant	3.800	0.622	-	-
GDP	-0.749	0.613	-0.0528	0.008
Construction	0.238	0.276	0.0101	0.086

Housing loans	0.266	0.036	-0.007	0.172
Interest rate on a housing loan	0.00091	2.1741	-4.717	3.697

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 3. Johansen cointegration: Estonia

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	58.61 [0.003]	27.58 [0.047]	48.63 [0.040]	22.89 [0.183]
1	0.443	31.03 [0.036]	20.99 [0.051]	25.74 [0.140]	17.41 [0.158]
2	0.360	10.04 [0.283]	7.72 [0.417]	8.33 [0.438]	6.40 [0.569]
3	0.151	2.32 [0.127]	2.32 [0.127]	1.93 [0.165]	1.93 [0.165]
4	0.048	-	-	-	-

Note: p-values in brackets; VAR includes 2 lags. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests except normality.
Source: Calculation of the author.

Table 3a. Johansen cointegration: Estonia

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.000	0.00	-0.115	0.073
GDP	-1.835	0.871	0.033	0.0103
Construction	0.385	0.511	-0.039	0.0449
Interest rate on a housing loan	0.040	0.008	-5.285	1.579

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 4. Johansen cointegration: Bulgaria

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	40.00 [0.002]	22.74 [0.027]	30.77 [0.038]	17.49 [0.155]
1	0.441	17.26 [0.025]	13.91 [0.055]	13.27 [0.105]	10.70 [0.172]
2	0.300	3.34 [0.068]	3.34 [0.068]	2.57 [0.109]	2.57 [0.109]
3	0.082	-	-	-	-

Note: p-values in brackets; VAR includes 3 lags. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests.
Source: Calculation of the author.

Table 4a. Johansen cointegration: Bulgaria

Variables	Long-run	Short-run

	β coefficients	st. errors	α coefficients	st. errors
House price	1.00	0.00	-0.042	0.025
GDP	-0.591	0.627	0.004	0.009
Interest rate on a housing loan	0.028	0.007	-17.00	3.61

Note: p-values in brackets; β coefficients are written in vector form, estimation starts from 1999q3.
Source: Calculation of the author.

Table 5. Johansen cointegration: United Kingdom (1995)

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	71.93 [0.000]	59.71 [0.000]	68.08 [0.000]	56.51 [0.000]
1	0.655	12.23 [0.437]	7.22 [0.649]	11.57 [0.496]	6.83 [0.693]
2	0.120	5.01 [0.293]	5.01 [0.292]	4.74 [0.324]	4.74 [0.323]
3	0.085	-	-	-	-

Note: p-values in brackets; VAR includes 2 lags and a restricted constant. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests.
Source: Calculation of the author.

Table 5a. Johansen cointegration: United Kingdom (1995)

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.000	0.00	0.127	0.028
Constant	11.53	1.576	-	-
GDP	-2.97	0.276	0.041	0.004
Interest rate on a housing loan	0.029	0.012	-0.901	0.706

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 6. Johansen cointegration: United Kingdom (1969)

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	68.16 [0.000]	46.59 [0.000]	62.92 [0.000]	43.00 [0.000]
1	0.70	21.58 [0.031]	18.09 [0.020]	19.92 [0.054]	16.70 [0.075]
2	0.37	3.49 [0.505]	3.49 [0.504]	3.22 [0.550]	3.22 [0.549]
3	0.085	-	-	-	-

Note: p-values in brackets; VAR includes 1 lag and a restricted constant. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests.
Source: Calculation of the author.

Table 6a. Johansen cointegration: United Kingdom (1969)

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.000	0.00	-0.057	0.019
Constant	-0.233	0.854	-	-
GDP	-1.364	0.297	-0.036	0.0041
Interest rate on a housing loan	0.00101	0.0082	-0.475	1.508

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 7. Johansen cointegration: Ireland

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)
0	-	135.24 [0.000]	63.20 [0.000]	110.19 [0.000]	51.50 [0.000]
1	0.689	72.03 [0.000]	42.40 [0.000]	58.69 [0.017]	34.55 [0.006]
2	0.544	29.63 [0.178]	14.40 [0.439]	24.14 [0.459]	11.74 [0.685]
3	0.234	15.22 [0.218]	9.54 [0.391]	12.40 [0.422]	7.77 [0.585]
4	0.161	5.69 [0.224]	5.69 [0.224]	4.63 [0.337]	4.63 [0.336]
5	0.099	-	-	-	-

Note: p-values in brackets; VAR includes 2 lags and a restricted constant. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests.
Source: Calculation of the author.

Table 7a. Johansen cointegration: Ireland

Variables	Long-run		Short-run		Joint restrictions Chi^ 2(5)= 1.11 [0.95]	
	β coefficients	st. errors	α coefficients	st. errors		
House price	1.00	0.00	0.054	0.00	β=1	$\alpha_{house\_price} = \alpha_{GDP}$
Constant	0.00	0.00	-	-	β=0	-
GDP	-0.781	0.00	0.054	0.0096	$\beta_{GDP} = -\beta_{constr}$	-
Construction	0.781	0.038	0.00	0.00	-	α=0
Housing loans	-0.674	0.0384	0.077	0.0096	-	-
Interest rate on a housing loan	0.011	0.007	0.00	0.00	-	α=0

Note: β coefficients are written in vector form.
Source: Calculation of the author.

Table 8. Johansen cointegration: Spain

Rank	Eigenvalue	Trace test	Max test	Trace test (T-nm)	Max test (T-nm)

0	-	54.37 [0.000]	29.89 [0.002]	38.69 [0.019]	21.27 [0.068]
1	0.437	24.48 [0.011]	15.32 [0.060]	17.42 [0.118]	10.90 [0.268]
2	0.255	9.16 [0.050]	9.16 [0.050]	6.52 [0.159]	6.52 [0.159]
3	0.161	-	-	-	-

Note: p-values in brackets; VAR includes 5 lags and a restricted constant. Lag length chosen according to SBIC.

VAR residuals satisfy all diagnostic tests.

Source: Calculation of the author.

Table 8a. Johansen cointegration: Spain

Variables	Long-run		Short-run	
	β coefficients	st. errors	α coefficients	st. errors
House price	1.00	0.000	0.0009	0.0015
Constant	1.027	31.002	-	-
GDP	-1.076	5.799	0.0025	0.0008
Interest rate on a housing loan	0.0322	0.193	-0.752	0.1709

Note: β coefficients are written in vector form.

Source: Calculation of the author.