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Short-run and Long-run Determinants of House Prices in Eastern and Western European Countries

RESEARCH PAPER

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Abstract

This paper uses cointegration and error-correction models to examine the long-run and short-run behavior of house prices in Eastern and Western European countries. Four post-transition (Bulgaria, Croatia, the Czech Republic, and Estonia) and three developed EU countries (Ireland, Spain, and the U.K.) are included in the sample. House price behavior for each country is modeled separately as a function of income, interest rates, credit, construction activity, and employment. The results of the empirical analysis suggest that, in the long run, interest rate changes explain house price behavior in both groups of countries, while income changes are only relevant for Western European countries. Along with interest rates and income, house prices in both groups of countries react in the short run to changes in the construction activity. Moreover, house price persistence is important for short-run house price changes in both groups of countries. Housing loan changes also affect the short-run house price behavior, but this effect is limited to Eastern European countries.

Keywords: determinants of house prices, housing markets, cointegration, Central and Eastern Europe, Western Europe
JEL classification: C22, R21, R31

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1 Introduction[1]

House prices and their links to macroeconomics in developed countries have been the subject of an increasing body of empirical work. In the last few years research interest in housing markets has intensified because of the role that housing markets have played in the global economic crisis. However, the boom-bust cycle in house prices is not unique to developed countries, as similar or even more pronounced house price developments have been observed in the countries of the former Soviet Union (Stepanyan, Poghosyan and Bibolov, 2010), Eastern Europe (Posedel and Vizek, 2009), and the Middle East (Beidas-Strom, Weicheng and Maseeh, 2009).

The last decade has witnessed increased interest in analyzing house price determinants from country-by-country or cross-country perspectives in emerging economies in general, and in Eastern European countries in particular. Several studies also compare house price behavior in these countries to that in developed economies. This paper contributes to the literature by conducting a country-by-country analysis with a comparison of results across countries. We ask the following question: What are the most important house price drivers in Eastern European countries? How does house price behavior in the short run differ from the long run? What are the key similarities and differences between Eastern European and developed European Union countries when it comes to house price drivers?

In order to obtain answers to these questions, this paper uses Johansen cointegration and vector error-correction models. To the best of the author's knowledge, there are no empirical papers which model house prices on a country-by-country basis using the cointegration and error-correction models. A total of seven countries are included in the sample: four transition economies (Bulgaria, Croatia, the Czech Republic, and Estonia) and three developed EU economies (Ireland, Spain, and the U.K.). The data

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range differs across countries: the data span for the transition countries is somewhat shorter compared to the developed countries (where it starts from 1995:Q1), e.g., the starting observation for Croatia is 1996:Q4, for Estonia 1997:Q1, and for Bulgaria and the Czech Republic 1998:Q1.

The remainder of the paper is organized as follows. Section 2 reviews the literature on house price modeling in Central and Eastern Europe. Section 3 presents the data and the methodology applied and discusses the results of the empirical analysis. Section 4 summarizes the main findings.

2 Literature Review

A growing body of literature on house price dynamics in developed countries does not offer a unifying explanation for house price cycles (Leung, 2004). However, the relevance of income and interest rates as house price drivers is confirmed in the majority of the studies. For example, Sutton (2002) confirmed, using VAR, the relevance of income and interest rates for Australia, Canada, Ireland, the Netherlands, the U.K., and the U.S.A. McQuinn and O'Reilly (2008) and Pagés and Maza (2003) come to the same conclusion using cointegration analysis on Irish and Spanish data, respectively. Abelson et al. (2005) and Posedel and Vizek (2010) applied a threshold error-correction model to the data for Australia and the U.S.A., and showed that, in the long run, real house prices were determined, among others, by income and interest rates. Meen (2002) estimated long-run income elasticities of house prices in the U.S.A. and the U.K. and concluded they were very high (2.71 and 2.51, respectively). Schnure (2005) analyzed panel data for the U.S. regions and also concluded that changes in income explained house price changes. However, his findings suggested that interest rates were not relevant for the determination of house prices.

Apart from income and interest rates, some studies for developed countries also suggest that financing conditions (Tsatsaronis and Zhu, 2004), construction costs (Hort, 1998), unemployment (Schnure, 2005), inflation (Tsatsaronis and Zhu, 2004), housing stock (Abelson et al., 2005), equity prices (Abelson et al., 2005; Sutton, 2002), and house price persistence (Hort, 1998; Annett, 2005) could be the relevant house price determinants in developed countries.

Unlike developed countries, house prices in European transition countries have been less extensively researched.[2] Papers like Egert and Mihaljek (2007), Posedel and Vizek (2009; 2010), Stepanyan, Poghosyan and Bibolov (2010), Zemčík (2010), and Hlaváček and Komárek (2009) studied house price determinants in the region. The first empirical study of house prices in European transition countries was done by Egert and Mihaljek (2007). The authors estimated panels composed of eight transition and 19 developed OECD economies. Given the limited data availability, their modeling strategy consisted of reserving two explanatory variables for income and interest rates, while the third explanatory variable was varied. The results of their empirical exercise indicated that per capita GDP, real interest rates, credit growth, demographic factors, and indicators of institutional development of housing markets and housing finance were important house price drivers.

Posedel and Vizek (2009) 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, interest rates accounted for the largest portion of the house price variance in the U.K. and Estonia. Moreover, house prices in the three EU-15 countries accounted for a significant fraction of the GDP, construction activity, and interest rates variance. However, this was not the case for the Eastern European countries. In both groups of countries supply-side factors did not determine house prices in the short run.

Stepanyan, Poghosyan and Bibolov (2010) used a panel data approach to model house price behavior in the former Soviet Union countries (FSU countries). Given that the Central Asian FSU economies experienced

[2] *Palacin and Shelburne (2005) provide a detailed description of the housing markets and their fundamentals in Central and Eastern Europe.*

strong inflows of unilateral transfers (i.e., remittances) and significant capital inflows, the authors used these two variables in their house price model, along with other standard explanatory variables. The results of their study suggested that real GDP, remittances, and foreign inflows influenced house prices in the FSU countries.

Posedel and Vizek (2010) used a nonlinear framework to identify house price determinants and adjustment properties. They used a sample of four developed countries, including the U.S.A., and four Eastern European countries. They showed that the house price adjustment process in transition countries and the U.S.A. was characterized by threshold effects. Namely, the adjustment is faster when actual prices are below the equilibrium prices, while the opposite is true when prices are above the level warranted by the fundamentals. Contrary to Stepanyan, Poghosyan and Bibolov (2010), Posedel and Vizek showed that the house price adjustment parameters were quite small if modeled in a threshold error-correction framework, suggesting that house prices took a long time to correct the discrepancies from equilibrium. Moreover, within the threshold error-correction framework, changes in the GDP Granger-caused house price changes in Estonia and the U.S.A., while interest rate changes Granger-caused house prices changes in Bulgaria, Croatia, and the U.S.A.

Zemčík (2010) did not focus on house price determinants, but rather on the relationship between house prices and rents in the Czech Republic. In order to establish whether there was a housing market bubble in the different regions, capital city, and its districts, the author used the present value model framework and panel data unit root and causality tests. The results of his panel data estimates suggested that, out of 57 tested regions, in 44 (mostly bigger cities) a bubble could be identified.

Hlaváček and Komárek (2009) looked at fundamentals of house prices in the Czech Republic. Using regression and panel data models they confirmed the importance of the unemployment rate, wages, and credit for house price developments. The demographic factors, net migration, and divorce rate also explained a part of the house price variance in the Czech Republic.

3 Data and Methodology

3.1 Data

In this section we briefly describe the methodology and the data. As stated earlier, the sample includes three developed EU countries (Ireland, Spain, and the U.K.) and four Eastern European transition countries (Bulgaria, Croatia, the Czech Republic, and Estonia). The Eastern European countries included in the sample are the only countries for which the author could obtain longer house price series from official, non-commercial sources. In the case of Croatia, data are provided by a commercial database also used by the Croatian National Bank for calculation of the hedonic house price index (Kunovac et al., 2008). Data for developed countries start from 1995:Q1. The last observation available for Ireland is 2009:Q1. For the other three countries data extend to 2009:Q2. As house price data for the U.K. are available from 1969, we estimated cointegration and error-correction models for the U.K. on shorter and longer samples.

The longest sample for transition countries is available for Croatia (from 1996:Q4). Data for Estonia start in 1997:Q1, while for Bulgaria and the Czech Republic the starting observation is 1998:Q1. Data series for all transition countries end with 2009:Q2 (for the Czech Republic 2008:Q4). As evident in Appendix I, where details on all series used in the analysis are displayed, house price data are not homogenous across countries. House price series for Estonia, the Czech Republic, and Spain encompass new and used apartments, while series for the United Kingdom and Ireland contain only new and used house prices and new house prices, respectively. House price series for Bulgaria and Croatia encompass both types of dwellings, but in the Bulgarian case only used dwellings are included, while in the Croatian case both new and used dwellings are included. For all countries except Estonia, a national house price series is available. In the Estonian case, a house price series for the capital city is used.[3] Given the observed heterogeneity of house price data for countries in the sample, which in

[3] *The house price series for the capital city for the period 2002–2009 is highly correlated with the national series both in levels and annual growth rates.*

some cases precludes direct comparisons between countries, we feel it is more appropriate to analyze each country individually, rather than use panel data models.

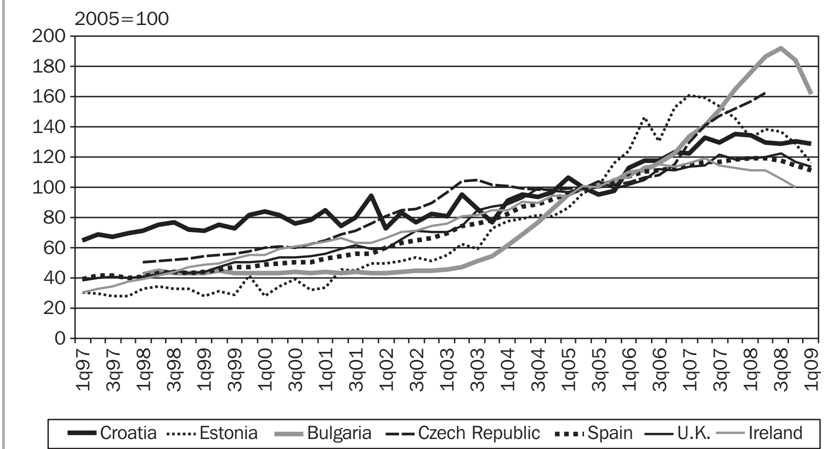
In addition to the house price series, the data set for each country includes quarterly real GDP series, interest rates on housing loans, total housing loans, employment, and construction activity. These series are in general calculated using similar or the same methodology and are therefore comparable across countries. Further details on the data series are available in Appendix I.

The series are expressed in real 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.[4]

Figure 1 displays nominal house prices for Croatia, Bulgaria, Estonia, the Czech Republic, Ireland, Spain, and the United Kingdom from 1997:Q1 to 2009:Q2. All countries experienced substantial increases in house prices. However, during 2007 and 2008, the price trend reversed and countries that had witnessed the most pronounced house price booms experienced pronounced house price declines. The figure also shows that two transition countries (Estonia and Bulgaria) exhibited the most intensive house price appreciation. Although some similarities in house price cycles across countries exist, one cannot conclude that all countries in the sample share a similar house price trend.

[4] *To save space we do not show the results of unit root tests here. However, they are available from the author upon request.*

Figure 1 **Nominal House Price Developments**



Sources: Burza nekretnina (Croatia), Statistics Estonia, National Statistical Institute (Bulgaria), Czech Statistical Office, Department for Communities and Local Government (U.K.), National Statistics Institute (Spain), and Department of the Environment, Heritage and Local Government (Ireland).

In order to get a better grasp of the intensity of house price appreciation and subsequent correction, Table 1 displays cumulative increases and decreases of house prices. One can notice that there are substantial differences in both cumulative house price appreciation and the correction that followed. The highest house price increase was recorded in Estonia and Bulgaria, where prices rose by 394 and 355 percent over a nine- and ten-year period, respectively. On the other hand, the house price increase in the Czech Republic seems in line with those developed countries that experienced house price booms, while the house price increase in Croatia seems comparatively modest. As against the Eastern European countries, house price inflation in the three Western European countries followed a similar path: in all three countries prices have tripled in approximately eleven years.

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

Table 1 **Nominal House Price Appreciation and Subsequent Correction (1998:Q1–2009:Q2)**							
	Bulgaria	**Croatia**	**Czech Republic**	**Estonia**	**Ireland**	**Spain**	**U.K.**
Cumulative appreciation (in %)	355	89	221	394	205	193	199
House price peak	2008:Q3	2007:Q4	-	2007:Q1	2007:Q2	2008:Q1	2007:Q3
Cumulative correction (in %)	19	5	-	39	19	7	7

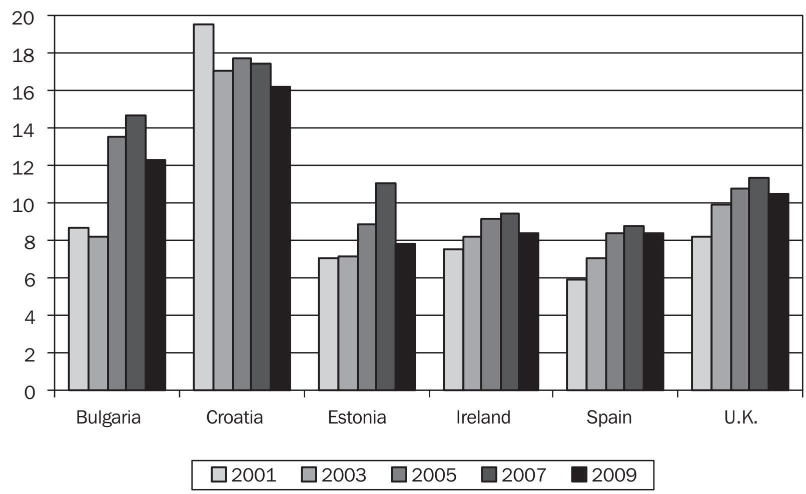
Sources: Burza nekretnina (Croatia), Statistics Estonia, National Statistical Institute (Bulgaria), Czech Statistical Office, Department for Communities and Local Government (U.K.), National Statistics Institute (Spain), and Department of the Environment, Heritage and Local Government (Ireland).

Before turning to the empirical analysis, it is useful to take a look at housing affordability indices. OECD (2005) and IMF (2004) use housing affordability indices as indicators of over- or under-valuation of housing, under the condition that these indicators are available for longer time periods.[5]

Looking at housing affordability is useful because the index compares house price to household income which is a macroeconomic fundamental. If their relationship is not mean reverting over time, this might suggest that house prices do not reflect the changes in fundamentals well. In Figure 2 we present housing affordability indices calculated according to the so-called "shelter first approach" (Robinson, Scobie and Hallinan, 2006) which assumes that outlays for housing are always paid first, while the residual part of income is used for other types of consumption and/or savings. As a measure of income we used official GDP per capita in euros that includes a correction for the unofficial economy. House prices refer to the price of a square meter of housing (also expressed in euros). When interpreting the indices, one has to keep in mind that GDP per capita is not an ideal choice for measuring household income, which in turn may blur the results of the analysis. One interprets the affordability index in the following way: the higher the value of the index, the lower the housing affordability. Moreover, if the value of the index is higher than its long-run average, it may indicate that house prices are overvalued.

[5] *For the same purpose one could analyze price-to-rent ratios, but unfortunately data on rents for three out of four transition countries are not available.*

Figure 2 **Housing Affordability Indices***



*Note: * Housing affordability index in a given year is defined as a ratio of average sales price of one square meter of housing and GDP per capita recorded in that year, multiplied by 100.*
Sources: Eurostat, Burza nekretnina (Croatia), Statistics Estonia, National Statistical Institute (Bulgaria), Department for Communities and Local Government (U.K.), National Statistics Institute (Spain), and Department of the Environment, Heritage and Local Government (Ireland).

Figure 2 shows that during 2007, when prices were at their peak in all countries except Bulgaria and Spain (where the peak occurred a year later), the housing affordability was lower in three Eastern European countries relative to the three EU-15 countries, even though the level of house prices in Eastern Europe was significantly lower. This is due to the fact that the gap between the levels of house prices in Western and Eastern Europe was narrower when compared to the gap between the levels of household income proxied by GDP per capita. When observing each country individually, one notices that in absolute terms housing was the least affordable in Croatia. The fact that in Croatia housing was relatively unaffordable as early as 2001, combined with slower growth of income than in other transition economies, might explain the relatively modest house price appreciation experienced in Croatia. The affordability of housing decreased over time the most in Estonia and Bulgaria, which also experienced the most pronounced run-up in house prices. One must also note that affordability in these two countries lowered despite strong growth of per capita GDP (by 100 and 135 percent, respectively, in cumulative terms over 2001–2009). However, affordability improved in all countries during 2009 as a result of the house price corrections.

3.2 Methodology

The cointegration approach to the analysis of asset prices was first introduced by Campbell and Shiller (1987), who tested the present value model for bonds and stocks. Following them, many authors including Hort (1998), Malpezzi (1999), Meen (2002), Pagés and Maza (2003), and Mikhed and Zemčík (2009) applied cointegration in order to model house prices in developed countries.

To determine whether the house prices form an equilibrium relationship with macroeconomic fundamentals in the long run, we use the Johansen procedure, i.e., trace and max statistics. These two test statistics also determine the number of cointegrating vectors between variables (Johansen, 1988; 1991). The 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 than the asymptotic theory would suggest when there is a large number of variables and lags in VAR, Cheung and Lai (1993), Ahn and Reinsel (1990), and Reimers (1992) suggest a finite sample correction which is particularly useful for our analysis, since we have a small sample size and a large number of variables and lags included in the cointegration space. 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 a different number of cointegrating vectors compared to their asymptotic counterpart, the final decision on the number of vectors is based on the corrected test statistics.

We begin the cointegration analysis by estimating a VAR in the form of Equation 1. In it, *k* represents country, and $Y_{k,t}$ is a (6x1) vector containing the values that six variables assume at time *t*. $Y_{k,t}$ consists of six variables representing the demand side and the supply side of the housing market, as well as the financing conditions, i.e., real house price, real GDP, employment, real volume of housing loans, real interest rate on housing loan, and construction output index.

$$Y_{k,t}=c_k+\sum_{j=1}^{p}\Phi_{k,j}\,Y_{k,t-p}+\varepsilon_{k,t} \tag{1}$$

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

If 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. If the remaining four variables did not form a long-run relationship, we excluded the construction output index from the VAR, leaving just three variables: real house price, real GDP and real interest rates on housing loans. These three variables are most often used in empirical studies of the determinants of house prices. Moreover, these variables were the key variables Egert and Mihaljek (2007) used in their analysis of house price determinants in Central and Eastern European countries. We believe that it is appropriate to exclude employment and housing loans from the analysis because the remaining variables partially represent the excluded variables – GDP can be thought of as a proxy for employment, while interest rates on housing loans proxy for the availability of financing. In this way we obtained cointegration vectors for all the countries.

After we derived the long-run relationships, we estimated an error-correction model of house prices for each country. We followed a general-to-specific approach, instead of the standard vector error-correction model (VECM), mainly because VECM is very inflexible in terms of its lag structure. Namely, in most cases cointegrating VAR included just two lags of endogenous variables, which requires that only one lag is used in VECM. Having just one lag (i.e., one quarter) of history in the short-run model is very limiting, especially if one assumes that house price persistence affects house price behavior.

At the beginning, we estimated a general unrestricted model (Equation 2) in which we regressed the first difference of real house prices (Δhp_t) (in logarithm) on the error-correction term (Δect_{t-1}), and the first difference of the GDP (Δgdp_{t-1}) (in logarithm), employment (Δemp_{t-1}), housing loans (Δhl_{t-1}), interest rates (Δir_{t-1}), and construction output (Δco_{t-1}). Due to the fact that several empirical papers confirmed that house price persistence (i.e., a tendency of real house prices to rise tomorrow if they rose today) is relevant for house price behavior,[6] we also included lagged values of the dependent variable (Δhp_{t-1}) in the estimation in order to be able to control for it.

$$\begin{aligned}\Delta \mathrm{hp}_t = \; & \mathrm{c} + \sum_{i=1}^{4} \Delta \mathrm{ect}_{t-i} + \sum_{i=1}^{4} \Delta \mathrm{hp}_{t-i} + \sum_{i=1}^{4} \Delta \mathrm{gdp}_{t-i} + \sum_{i=1}^{4} \Delta \mathrm{ir}_{t-i} + \\ & + \sum_{i=1}^{4} \Delta \mathrm{emp}_{t-i} + \sum_{i=1}^{4} \Delta \mathrm{hl}_{t-i} + \sum_{i=1}^{4} \Delta \mathrm{co}_{t-i} + \varepsilon_t \end{aligned} \tag{2}$$

All independent variables, including the error-correction term, entered the general unrestricted model with four lags. We believe that it is appropriate to include lagged error-correction terms in the general unrestricted model because if lagged values of dependent variables are statistically significant (thus implying the presence of house price persistence), one can expect that house prices take a longer time to react to changes in fundamentals represented in the error-correction term. If, however, no house price persistence is present, one can expect that the results of the analysis will indicate that only the first lag of the error-correction term is relevant. The next step was to eliminate statistically insignificant terms from the model.

[6] *For example, Hort (1998) found evidence of house price persistence for Sweden, Lamont and Stein (1999) for the U.S.A., Annett (2005) for EU-15 countries, and Posedel and Vizek (2009) for Eastern European countries. One might expect house price persistence exists because of rigidities inherent to the housing markets, but also due to the role expectations may play in the determination of house prices. Including lagged values of the dependent variable on the right hand side does not complicate the econometric procedure, because time series analysis is, in general, atheoretical and assumes that lagged values of the dependent variable are included in the model as explanatory variables.*

This leads to the derivation of the final error-correction model, which must 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 could be found, which enabled us to determine long-run parameters directly. The details on trace and max statistics can be found in Appendix II. In the case of Ireland, two cointegrating vectors were found, which required the imposition of at least four restrictions on the cointegrating space in order to identify the long-run parameters. These restrictions and the corresponding coefficients are presented in Table A5a.

Table 2 displays the long-run elasticities of house prices with respect to other variables, along with the results of the zero restrictions test (calculated as Chi^2 statistics) on each individual long-run elasticity. This table thus indicates which variables were used in order to obtain a cointegrating relationship, while Chi^2 statistics and corresponding p-values suggest which of the variables entailing the long-run relationship are not statistically significant. One can notice that in the case of Croatia, Bulgaria, the U.K., and Spain, house prices seem to form a relationship with GDP (which proxies both income and overall economic activity) and interest rates (which represent the financing conditions and the 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 Table 2 that although the GDP and interest rates are relevant for house price behavior in the long run, the GDP coefficient is statistically significant only in the case of Spain and the U.K. (1995 sample), while the interest rate is significant for all countries except Spain. Long-run elasticities of house prices with respect to interest rate changes have the expected sign, but vary considerably across countries (from 0.01 for the

U.K. [1969–2008 sample] to -4.0 for Estonia). In three out of seven countries the supply of new housing units also enters the long-run relationship, but after imposing the zero restriction on this variable, it turns out that only in Ireland increased construction activity leads to lower house prices in the long run. However, the value of this elasticity for Ireland is lower than 1 in absolute terms. One should note that if we were to use the housing stock variable instead of the construction output index, housing supply might have a more important role in affecting house prices in the long run. Unfortunately, housing stock series for Eastern European countries are not available, so we are not in a position to test this conjecture. Finite sample corrections of trace and max statistics did indicate that housing loans were relevant for house price behavior in the Czech Republic and Ireland, but after testing for the zero restrictions it turned out that these long-run elasticities were not significantly different from zero.

What one can conclude from this analysis is that, in the long run, interest rate changes explain house price behavior in the majority of countries, while income changes are only relevant for two developed countries. Construction activity matters only in Ireland, while housing loans are statistically insignificant in the two cases where they entered the cointegrating relationship.

It is also worth comparing the results for the U.K. for the longer and shorter samples. Corrected trace and max statistics suggested in both cases that cointegration existed between house prices, real GDP, and interest rates. However, income and interest rate elasticities in the model estimated on the sample dating back to 1969 were much smaller when compared to the model estimated on the data starting in 1995. The difference was particularly pronounced for the interest rate elasticity, which increased from 0.1 in the longer sample to 2.9 in the shorter sample. This might suggest that the influence of financial sector developments on the housing market has increased over time.

Table 2 **Long-run Elasticities of House Prices and Corresponding Zero Restrictions**

Variable	**House price**		**Constant**		**GDP**		**Construction**		**Housing loans**		**Interest rates (housing loans)**	
Country	β	$\beta=0$	β	$\beta=0$	β	$\beta=0$	β	$\beta=0$	β	$\beta=0$	β	$\beta=0$
Bulgaria	1.0	4.35* [0.04]	-	-	0.591	0.244 [0.62]	-	-	-	-	-2.8	5.82* [0.015]
Croatia	1.0	11.01** [0.001]	2.93	10.21** [0.001]	0.037	0.038 [0.84]	-	-	-	-	-2.1	11.92** [0.001]
Czech Rep.	1.0	8.75** [0.003]	3.80	1.15 [0.28]	0.749	0.594 [0.44]	-0.24	0.28 [0.59]	-0.27	0.013 [0.91]	-0.09	8.93** [0.003]
Estonia	1.0	10.62** [0.001]	-	-	1.835	1.77 [0.18]	-0.39	0.17 [0.68]	-	-	-4.0	5.04* [0.03]
Ireland	1.0	18.7** [0.00]	-	-	0.781	0.05 [0.81]	-0.781	7.4** [0.006]	0.67	1.65 [0.19]	-1.1	4.62* [0.04]
Spain	1.0	5.41* [0.03]	1.027	0.0004 [0.98]	1.076	4.87* [0.03]	-	-	-	-	-3.2	0.167 [0.73]
U.K. (1995)	1.0	22.9** [0.00]	-11.5	12.83** [0.00]	2.97	16.1** [0.0001]	-	-	-	-	-2.9	4.97* [0.03]
U.K. (1969)	1.0	4.3* [0.04]	0.233	1.35 [0.24]	1.364	0.005 [0.94]	-	-	-	-	-0.1	15.2** [0.001]

*Notes: **Significant at 1 percent level; *significant at 5 percent level; zero restriction on long-run elasticities is tested using the likelihood ratio test of restriction with Chi^2 statistics; numbers in brackets denote the p-values.*
Source: Author's calculations.

Table 3 presents the adjustment coefficients that are estimated along with the long-run coefficients in cointegration space. By testing the zero restriction on individual adjustment coefficients, we establish which variables are weakly exogenous, i.e., which variables in the short run do not correct the deviations from the long-run equilibrium. This is important because, although the Granger representation theorem suggests that there must be an error-correction mechanism if the series in question are cointegrated, error-correction terms in error-correction models with weakly exogenous series as dependent variables will not be statistically significant. This is due to the fact that weakly exogenous series by definition do not adjust the discrepancies from equilibrium and relinquish the adjustment to other series in cointegrating relationship that are not weakly exogenous. From Table 3 we can notice that house prices are weakly exogenous in Bulgaria, Estonia, and Spain. In the case of the U.K. (1995 sample) and Ireland we observe that house prices are not weakly exogenous, but they adjust in the opposite direction, meaning that their short-run behavior even increases the long-run discrepancy with respect to the fundamentals. As far as other variables are concerned, the GDP corrects the discrepancies from equilibrium in all countries except Bulgaria, while interest rates are not weakly exogenous in three transition countries (Bulgaria, Croatia, and Estonia) and Spain. As with house prices, in most cases where the GDP and interest rates are not weakly exogenous, their short-run behavior decreases the disequilibrium (i.e., the adjustment coefficients have the right sign). The exceptions are rather small negative GDP adjustment coefficients for the Czech Republic and the U.K. (1969 sample), and a small positive interest rate coefficient for Ireland.

Table 3 **Adjustment Coefficients and Weak Exogeneity Tests**

Variable	**House price**		**GDP**		**Construction**		**Housing loans**		**Interest rates (housing loans)**	
Country	α	α=0	α	α=0	α	α=0	α	α=0	α	α=0
Bulgaria	-0.042	1.61 [0.20]	0.004	0.209 [0.65]	-	-	-	-	-17.0	8.71** [0.003]
Croatia	-0.377	6.36* [0.011]	0.100	4.17** [0.041]	-	-	-	-	-9.01	6.64** [0.01]
Czech Rep.	-0.087	5.7* [0.02]	-0.05	10.5** [0.001]	0.01	0.01 [0.91]	-0.01	0.002 [0.96]	-4.71	0.90 [0.34]
Estonia	-0.115	1.528 [0.21]	0.033	4.20* [0.04]	-0.04	0.405 [0.52]	-	-	-5.28	4.34* [0.04]
Ireland	0.0201	8.41** [0.003]	0.016	6.67** [0.009]	-0.01	0.22 [0.63]	0.026	19.6** [0.00]	0.090	0.06 [0.80]
Spain	0.0009	0.43 [0.50]	0.003	6.21* [0.012]	-	-	-	-	-0.75	11.8** [0.001]
U.K. (1995)	0.127	16.09** [0.0001]	0.041	45.98** [0.00]	-	-	-	-	-0.90	1.55 [0.21]
U.K. (1969)	-0.057	7.96** [0.005]	-0.04	28.4** [0.00]	-	-	-	-	-0.47	0.08 [0.77]

*Notes: **Significant at 1 percent level; *significant at 5 percent level; zero restriction on adjustment coefficients is tested using the likelihood ratio test of restriction with Chi² statistics; numbers in brackets denote the p-values.*
Source: Author's calculations.

Table 4 summarizes the results of error-correction models. As one can notice, country models satisfy all diagnostic tests. Furthermore, in all countries except Estonia house prices are not weakly exogenous, i.e., they respond to deviations from the long-run equilibrium. This should not come as a surprise given that the weak exogeneity tests also indicated that house prices in Estonia were not responding to discrepancies in fundamentals. Moreover, the adjustment parameters are quite low for Spain and the Czech Republic. On the opposite end of the spectrum are Bulgaria and Croatia, where house prices adjust for about half of the deviation from the long-run equilibrium in a single quarter. The adjustment parameter for the U.K. (1995 sample) is positive and very similar (both in terms of the sign and size) to the adjustment parameter reported in Table 3. This suggests that in the U.K. the GDP in the 1995–2009 period corrected the long-run discrepancies on the housing market, and not house prices.

Lagged values of house prices are significant in all countries except Ireland, suggesting that house price persistence is a widespread phenomenon. Judging from the magnitude of lagged house price coefficients – from 0.42 in Bulgaria to 0.86 in Croatia – house price persistence elasticities are quite high. In addition, error-correction estimates for the two U.K. models suggest that house price persistence in the U.K. strengthened over time. This finding confirms earlier studies by Hort (1998), Lamont and Stein (1999), Annett (2005), and Posedel and Vizek (2009), which also concluded that the house price behavior was characterized by persistence.

In addition to house price persistence, the results of the error-correction model also reveal the importance of income as a house price determinant. Income is significant and correctly signed in all countries, with most elasticities around 1. Along with income, employment also seems to influence the short-run behavior of house prices in Croatia and the U.K.

Table 4 **Error-correction Model: Summary of Estimation Results**

Explanatory variables	**Bulgaria**	**Croatia**	**Czech Republic**	**Estonia**	**Ireland**	**Spain**	**U.K. (1995)**	**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)
Adj. R^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]

*Notes: **Significant at 1 percent level; *significant at 5 percent level; numbers in parentheses denote the time lag; numbers in brackets denote the p-value.*
Source: Author's calculations.

Interest rates are significant in all the countries except Estonia and Spain, with elasticities ranging from -0.3 in the U.K. (1969 sample) to -1.7 in Bulgaria. The smallest interest rate coefficient is found for the Czech Republic (0.25), but this coefficient is incorrectly signed. In Estonia housing loans rather than interest rates affect the short-run behavior of house prices. Housing loans are also significant in two other transition countries, Bulgaria and Croatia. Unlike transition countries, in developed countries housing loans do not seem to influence house prices in the short run. This phenomenon might be explained by the fact that in these countries house prices react to interest rates on housing loans, a variable that, like housing loans, proxies the availability of housing finance. Moreover, long-run coefficients also suggest that house prices react to interest rates on housing loans, and not to housing loans.

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 note, however, that construction output elasticities are higher in transition countries than in developed countries, although they are generally lower than 1 in absolute terms.

The two error-correction models for the U.K. provide similar results as the two cointegration models. The magnitude of the short-run interest rate elasticity and house price persistence has increased over time. However, unlike cointegration models, the 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 modeling both the long- and short-run house price determinants, we wanted to explore the key similarities and differences between Eastern and Western European countries.

The results of this study suggest that both income and interest rates enter into a long-run cointegration relationship with house prices, thus supporting the findings of earlier papers written by Egert and Mihaljek (2007), Posedel and Vizek (2009), and Hlaváček and Komárek (2009). However, in the majority of cases interest rates cannot be excluded from the model, while income can. Thus, only interest rate changes explain house price behavior in the majority of the countries in the long run, while income changes are only relevant for two developed countries (Spain and the U.K.). The prevalence of financing conditions for determining the house price was not remarked in earlier analyses of house price determinants in transition countries, but was indicated as important in industrialized countries by Tsatsaronis and Zhu (2004) and Annett (2005).

The supply of new housing, proxied by the construction activity index, enters into a long-run relationship in the case of the Czech Republic, Estonia, and Ireland, but only in the Irish case it cannot be restricted to zero. Housing loans are statistically insignificant in those cases where they entered the cointegrating relationship. This finding suggests that, in the long run, financing conditions matter more for determining house prices than income developments. Comparing the results for the U.K. on a longer (1969) and shorter (1995) sample corroborates this conclusion. Namely, both income and interest rate elasticities in the 1969 model are much smaller in magnitude when compared to the 1995 model. This difference is particularly evident for the interest rate elasticity, which increased from 0.1 to 2.9. This may suggest that financial sector developments, in both Eastern and Western Europe, matter significantly for house price changes in the long run, and that their influence on house prices has increased over time.

Error-correction model estimates also suggest that income and interest rates significantly affect the behavior of house prices. Its estimates suggest that house prices in all countries except Estonia correct for deviations from the long-run equilibrium. The adjustment parameters are quite low for Spain and the Czech Republic, while in Bulgaria and Croatia (where house prices adjust for about half of the deviation from the long-run equilibrium in a single quarter) the adjustment is relatively swift.

In addition to income and interest rates, lagged values of house prices are significant in all countries except Ireland, suggesting that house price persistence is a widespread phenomenon. The error-correction estimates for the two U.K. models also suggest that the house price persistence in the U.K. increased over time. This finding corroborates earlier studies by Hort (1998), Lamont and Stein (1999), Annett (2005), and Posedel and Vizek (2009; 2010), which also suggested that the house price behavior in Eastern and Western European countries was characterized by persistence. Although one cannot know precisely what residual information exists in lagged values of house prices, the most likely factors driving the persistence may include expectations and idiosyncratic institutional characteristics such as illiquid real estate markets, inadequate property rights protection, high transaction costs, and underdeveloped financial instruments.

Appendix I

Description and Sources of Data

Country: **Bulgaria**
Data range: 1998:Q1–2009:Q2

House price	National Statistical Institute	Average market prices of used dwellings in Bulgaria, in EUR.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, 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 million EUR.
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.

Note: All data for Bulgaria from domestic sources are originally denominated in domestic currency, but for the purpose of analysis are recalculated to euro values.

Country: **Croatia**
Data range: 1996:Q4–2009:Q2

House price	Real Estate Exchange Database (*Burza nekretnina*)*	Average sale price of all housing units (houses and apartments, new and used) in Croatia, in EUR.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, chain-linked volumes, reference year 2000 (at 2000 exchange rates).
Construction production index	Croatian Bureau of Statistics	Volume of construction work undertaken by legal entities with 25 or more employees, 2000=100.
Number of employed persons	Croatian 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 from July 1999; before July 1999 the series is compiled using growth rates of total loans to households, in million EUR.
Interest rate on housing loans	Croatian National Bank	Average annual interest rates on housing loans are available since January 2002; before 2002 average annual interest rate for long-term housing loans with currency clause.
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices.

Notes: * Burza nekretnina *is a commercial database containing all details on real estate sale transactions conducted by real estate agencies; all data for Croatia from domestic sources are originally denominated in domestic currency, but for the purpose of analysis are recalculated to euro values.*

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

House price	Czech Statistical Office	New and used apartment price indices for the Czech Republic; 2005=100.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, 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	Czech National Bank	Lending to households for long-term house purchase, in million 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.

Note: All data for the Czech Republic from domestic sources are originally denominated in domestic currency, but for the purpose of analysis are recalculated to euro values.

Country: **Estonia**
Data range: 1997:Q1–2009:Q2

House price	Statistics Estonia	Average sale price per square meter of two-room and kitchen dwellings of satisfactory condition in the capital city (Tallinn) intermediated by real estate agencies, in EUR. The series is highly correlated with average sale price series for entire Estonia which could not be used since it starts from 2002.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, 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 Estonia	Total housing loans, in million EUR.
Interest rate on housing loans	Bank of Estonia	Weighted average annual interest rate for housing loans granted to individuals.
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices.

Note: All data for Estonia from domestic sources are originally denominated in domestic currency, but for the purpose of analysis are recalculated to euro values.

Country: **Ireland**
Data range: 1995:Q1–2009:Q1

House price	Department of the Environment, Heritage and Local Government	Average price of new houses in Ireland, in EUR.
Gross domestic product	Central Statistics Office	Gross domestic product, in million EUR, chain-linked volumes, reference year 2000 (at 2000 exchange rates). The data for period 1995:Q1–1996:Q4 are compiled using quarterly growth rates of industrial production volume.
House completion index	Central Statistics Office	Calculated using the quarterly series of house completion number in all local authorities, 2000=100.
Number of employed persons	Central Statistics Office	Persons aged 15 years and over in employment, in '000.
Housing loans	Department of the Environment, Heritage and Local Government	Total housing loan payments, banks and building societies, in million EUR.
Interest rate on housing loans	Department of the Environment, Heritage and Local Government	Average annual building society mortgage interest rate.
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 Statistics Institute	Average price per square meter of new and used apartments for Spain, in EUR.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, 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 million EUR.
Interest rate on housing loans	Eurostat, Bank of Spain	For the period 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-year 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	Average sale prices of new and used houses, in £, converted to euros using average £/EUR exchange rate.
Gross domestic product	Eurostat	Gross domestic product, in million EUR, 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 million EUR, converted to euros using average £/EUR exchange rate.
Interest rate on housing loans	Bank of England	Average standard household variable mortgage rate.
CPI deflator	International Financial Statistics	Calculated by using quarterly base index of consumer prices, 2000=100.

Note: All data for the United Kingdom from domestic sources are originally denominated in domestic currency, but for the purpose of analysis are recalculated to euro values.

Appendix II

Estimation Results

Table A1 **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	-	-	-	-

Notes: p-values in brackets; VAR includes 3 lags. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests.
Source: Author's calculation.

Table A2 **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	-	-	-	-

Notes: 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: Author's calculation.

Table A3 **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	-	-	-	-

Notes: 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: Author's calculation.

Table A4 **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	-	-	-	-

Notes: p-values in brackets; VAR includes 2 lags. Lag length chosen according to SBIC. VAR residuals satisfy all diagnostic tests except normality.
Source: Author's calculation.

Table A5 **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	-	-	-	-

Notes: 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: Author's calculation.

Table A5a **Johansen Cointegration: Ireland**						
Variables	**Long-run**		**Short-run**		**Joint restrictions Chi²(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	αhouse price =αGDP
Constant	0.00	0.00	-	-	β=0	-
GDP	-0.781	0.00	0.054	0.0096	βGDP= -βconstr	-
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: Author's calculation.

Table A6 **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	-	-	-	-

Notes: 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: Author's calculation.

Table A7 **Johansen Cointegration: United Kingdom (1995:Q1–2009:Q2)**					
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	-	-	-	-

Notes: 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: Author's calculation.

Table A8 **Johansen Cointegration: United Kingdom (1969–2008, annual frequency)**					
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	-	-	-	-

Notes: 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: Author's calculation.

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