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## Abstract

The aim of this paper is to examine the interaction patterns between equity and real estate returns in 8 emerging economies from Central and Southeastern Europe. For that purpose we apply the TAR model entailing two regimes and endogenously determined threshold, delay parameter, and lag length. The results suggest that in all the countries, the interaction between equity and real estate returns is subject to regime switching in at least one direction. Equity returns in general seem to be much more sensitive to real estate returns changes, while the reaction of real estate returns to changes in equity returns is not always present and it is much more subdued and delayed. In the majority of the countries, the value of the threshold is large and negative suggesting that equity returns (real estate returns) react differently to large negative changes of real estate returns (equity returns) when compared to changes of different magnitudes and alternative signs. Equity returns react more strongly to large negative changes of the real estate returns than to small negative or positive real estate returns changes, while the reaction of the real estate returns to the equity returns changes varies across countries, making neither regime more prevalent.

**Keywords:** real estate prices, equity prices, regime switching, TAR model, emerging economies

**JEL Classification:** C33, F21, G11, G15, R31

## 1. Introduction

It has been long acknowledged that countless market activities generating the business cycle are interrelated. Disturbances in the market fundamentals generate movements of capital in and out of the affected market, thus influencing all interrelated markets. The interrelatedness of various markets grew rapidly in the last few decades, spurred by financial innovations and globalization of finance that followed after capital controls in the majority of developed and emerging countries were abolished in the 1980s and 1990s. In such a context it became increasingly challenging to optimize the return on investment portfolios by allocating resources across a number of different asset classes.

The aim of this paper is to look into the interrelatedness of two asset markets: real estate and equity markets. The potential for more intensive interaction, price co-movements, and even integration between these two markets has undoubtedly increased as a consequence of a growing level of financial globalization and innovation. Financial globalization and innovation tend to diffuse the barriers between once separate asset markets, thus creating the opportunities for combining different asset classes into one financial product. In such a way a framework which facilitates the direct interaction of different asset classes is created. As a result of this direct interaction, the segmentation that once existed between real estate and equity markets decreases and the co-movement of real estate and equity prices and

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returns increases. One can enumerate several channels that tied real estate and equity markets closer together, which in turn resulted in higher degree of real estate and equity price co-movements. Listing and trading with stocks of real estate companies represents one early channel of interaction between the two markets. This channel works in the following manner: when real estate price changes affect the profitability of the construction and real estate companies, they also affect their share prices, thus affecting the entire equity market. However, the importance of this channel was reduced with the introduction and development of real estate investment trusts (REIT) and various securitized mortgage products traded on the stock market. Although these products are in most cases limited to economies relying dominantly on equity financing, they add a very important channel for real estate and stock market interaction. Therefore, it should not come as a surprise that intertwining of real estate and stock markets has steadily increased over the years, culminating in the 2008 stock market crash. The crash and the financial crisis that followed were in part triggered by the last boom-bust cycle of the real estate markets and the ensuing massive losses of the financial sector associated with the securitization of mortgage products.

The aim of this study is to examine the short-run features of the relationship between the equity prices and the real estate prices in emerging countries. The contribution to the literature of this paper is threefold. This is the first study investigating the short-run relationship between real estate returns and equity returns on the sample of emerging countries in general, and on the sample of central and south-eastern European countries in particular. In addition, this is the first study that looks into possible non-linearities in the interaction between real estate returns and equity returns in these economies. While various other non-linear models have been employed in the real estate literature in order to investigate the non-linearities in the interaction between equity and real estate prices in developed countries, to the best of our knowledge, this is the first study that applies bivariate threshold autoregression model to the subject matter. By using an empirical method that was thus far somewhat neglected, and by offering comprehensive new evidence on the non-linear nature of the asset prices interactions in emerging economies, this study also complements earlier studies done for developed countries. Thereby, the non-linear approach in examining this relationship for developed countries, was advocated among others by Ambrose *et al.* (1992), Liow and Yang (2005), Liu and Su (2010), Okunev and Wilson (1997), and Okunev *et al.* (2000). Unlike those papers, we use bivariate threshold autoregression (TAR) which models the equity returns changes as a function of the real estate returns changes, while the real estate returns changes are modelled as function of the equity returns changes. A threshold estimate is obtained from grid-search algorithm, where returns of explanatory variables are also possible threshold values. The authors do not assert that equity returns are the only explanatory variable for real estate returns (or *vice versa*). Instead, both TAR model specifications simply explore the possibility of a threshold and deterministic regime switching in a single relation between the two variables.

There are several possible justifications for the application of the TAR model in order to model the short-run interactions between the equity prices and the real estate prices. First of all, it is a well-established empirical fact that asset prices are subject to threshold effects (Liu and Su 2010; Lizieri *et al.*, 1998; Maitland-Smith and Brooks 1999; Narayan 2005; Posedel and Vizek 2011; Shively 2003). Threshold effects may stem from the transaction costs inherent to all transactions with financial and real estate assets. Due to the fact that lower property right standards, underdeveloped financial markets, and less liquid property markets increase the transaction costs, threshold effects might be especially prominent in

the emerging economies. In addition, the TAR model might be particularly appropriate for equity price modelling, because it can mimic jump dynamics often observed in the stock prices behaviour (Tong and Lim, 1980).

The rest of the paper is organized as follows: Section 2 reviews relevant literature, and is followed by sections presenting the research data and the methodology. Section 5 provides the findings and a discussion of the empirical results. The final section provides an overview of the study.

## 2. Literature Review

The literature offers two main mechanisms explaining the co-dependent interactions between equity and real estate prices that lead to the integration of those two markets. The first mechanism is called the wealth effect. As aggregate consumption is a function of total wealth and labor income, whereby total wealth is comprised from financial wealth, housing and human wealth, one may expect that households with unanticipated gains in share prices will increase the consumption of housing, thus increasing the price of housing as well (Ando and Modigliani, 1963). Another mechanism that explains the interaction between stock and real estate prices is the credit-price effect, which is derived from the important role the balance sheet position and collateral value play for credit constrained firms (Capopoulos and Siokis, 2005). Hence, rising real estate prices increase the collateral value, reduce the cost of borrowing and increase the availability of finance. Due to stronger balance sheet position and higher collateral value, firms that owe real estate can realize capital gains, borrow at lower cost, and start new investment projects. In turn, their share prices rise as investors bid them up in expectation of increased revenues from new investment projects. Since new investment projects also demand more building sites and real estate, eventually the prices of both commercial as well as residential property rise again. Thus, the interaction of these two asset markets can lead to a spiralling upturn in both prices and explains why an exogenous shock causes persistent effect (Chen, 2001).

Empirical literature on the relationship between real estate and equity prices can be broadly divided in two strands. While the first strand investigates this relationship within a linear framework, often distinguishing between the short-run and the long-run features, the second strand aims to detect whether the nature of this relationship is non-linear. However, probably due to differences in the sample geographies and periods, data quality, and economic and institutional environments, the literature offers little consensus as to whether real estate and stock markets are integrated or segmented.

A very large body of academic literature has provided empirical evidence on the integration between real estate markets and stock markets in developed countries (see Anoruo and Braha, 2008; Gyourko and Kleim, 1992; Ling and Naranjo, 1999; Lizieri and Satchell, 1997; Miles *et al.*, 1990; and Tse, 2001). These authors employ linear methods and document evidence that corroborate the conclusion that the two markets are indeed increasingly co-dependent and integrated. The only study performed jointly for developed and developing countries (Čeh Časni, Vizek, 2014) also arrives at the same conclusion, but emphasise that integration decreased substantially after 2008 financial meltdown. In contrast, alternative stream of literature finds little, if any, evidence of integration between real estate and stock markets (see Geltner, 1990; Liu *et al.* 1990; Quan and Titman, 1999; and Wilson *et al.*, 1996).

Abovementioned studies start their analyses with the assumption that the interaction between equity and real estate prices in developed countries is in essence linear. However,

the linear models are misspecified if true data generating process is non-linear. Non-linear studies have yet to yield a unanimous conclusion, but the majority of those studies do indicate that some level of integration between stock markets and real estate markets in developed countries does exist. As far as we are aware, Liu and Su (2010) is the only study dealing with interaction patterns of real estate and stock prices for emerging countries.

Ambrose *et al.* (1992) test for nonlinear trends in the return series for different asset classes using rescaled range analysis and find no evidence that real estate markets proxied with REIT returns are not correlated with the stock market. As opposed to Ambrose *et al.* who tested for deterministic trend terms, Okunev and Wilson (1997) develop a non-linear test with a stochastic trend and detect a weak non-linear relationship between the US securitized real estate market and overall stock market. The authors, however, note that the mean reversion is very slow, resulting in prolonged periods of divergence between the two markets. Wilson and Okunev (1999) apply fractional integration and find evidence of long run co-memories between real estate and stock markets for Australia, but not for the US and the UK. Stronger evidence of integration is found if the sample is split on either side of the 1987 stock market correction. Okunev *et al.* (2000) applied both linear and non-linear causality tests to investigate the real estate and the stock market in the US. They found that the linear causality tests were spurious, whereas non-linear tests suggest a strong unidirectional relationship running from the stock market to the real estate market. Liow and Yang (2005) test for long run co-memories between real estate and stock markets using fractional cointegration and find evidence of integration in two out of four tested Asian economies. Liu and Su (2010) model the long-run interaction between equity and residential real estate prices in China using M-TAR cointegration and error-correction model. They detect significant regime switching in the mean reversion process and find a strong unidirectional causality running from the stock market to the real estate market.

### 3. Research Data

Our dataset entails quarterly real estate price indices and equity price indices for 8 Central and South-eastern European countries: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Lithuania, Russia, and Slovenia. We use the longest possible data range for each country in order to capture as many asset price cycles as possible. The shortest data range is available for Slovenia, where data are available from the first quarter of 2003 to second quarter of 2012. On the other hand, the longest data span, ranging from the first quarter of 1997 to the first quarter of 2012 is available for Estonia. The observed variety of data ranges between countries is a direct consequence of the unequal availability of real estate price series. As a rule we used the longest possible time span for all series in order to cover as many asset price cycles as possible. Due to the fact that some emerging countries did not publish real estate price statistics in the first decade of transition, data spans for Slovenia, Hungary and Russia are somewhat shorter when compared to other countries in the sample. However, as Posedel and Vizek (2009) point out, real estate price cycles in European emerging economies in post-transition period share many common features, which in turn means that the 5 year difference in the starting point of empirical analysis between the country with the longest, and the country with the shortest time span, should not preclude the comparability of empirical results. The comparability of results is also ensured by the fact that empirical analysis covers the same 9-year period for each analyzed country.

Table 1 | Descriptive Statistics and Unit Root Test

Country	Bulgaria		Croatia		Czech Republic		Estonia		Hungary		Lithuania		Russia		Slovenia	
	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns	Real estate returns	Equity returns
Observations	47	47	55	55	56	56	61	61	42	42	49	49	45	45	35	35
Mean	0.86	0.96	0.11	0.50	1.13	0.62	1.06	0.069	-0.82	0.83	1.86	1.75	1.49	2.1	1.09	-0.47
Standard Deviation	4.84	18.6	4.8	12.66	3.29	11.03	11.1	16.08	2.08	11.51	7.79	15.18	5.33	14.7	2.97	12.91
Skewness	-0.09	-1.93	0.34	-1.12	-0.12	-1.13	0.32	-0.31	-0.37	-0.88	-0.59	-1.13	-2.57	-1.1	0.22	-1.03
Excess Kurtosis	0.48	6.14	0.06	3.21	1.03	2.78	0.22	0.93	0.44	2.06	1.51	5.17	11.6	3.7	0.14	1.92
Minimum	-12.3	-81.4	-9.78	-50.4	-8.36	-43.65	-22.6	-46.3	-6.14	-40.07	-22.8	-63.0	-25.1	-55.4	-5.42	-44.9
Maximum	11.3	27.6	12.62	23.1	9.90	20.19	31.43	47.8	3.47	21.89	21.4	38.9	10.8	34.1	9.13	19.44
ADF test	-3.05*	-3.30*	-6.3**	-3.7**	-3.29*	-4.0**	-7.1**	-4.7**	-4.2**	-3.41*	-4.8**	-3.5*	-3.9**	-3.8**	-2.97*	-3.1*

Note: ADF test – Augmented Dickey-Fuller test; tests includes a constant; optimal lag length chosen by AIC.; \* null hypothesis of unit root rejected at 5 percent significance level; \*\* null hypothesis of unit root rejected at 1 per cent significance level.

Source: Calculation of the authors

The equity price developments are represented by quarterly stock market indices, which were collected from Bloomberg, and Eurostat. Following the approach of Anoruo and Braha (2008), Liu and Su (2010), Tse (2001), and Wilson *et al.* (1996), we use residential real estate prices as a proxy for real estate market developments. The data source for real estate price indices is the Property Price Statistics Database, compiled by the Bank for International Settlements. All data are seasonally adjusted using X12ARIMA and expressed as log-differences. Table 1 presents descriptive statistics and the ADF unit root tests for 16 variables used in our study, while Table A1 available in the Appendix enlists all relevant information regarding data properties and the sources for each of the 8 countries included in our analysis. The residential real estate returns in the analysis serve as a dual role: they are used as a proxy for the residential real estate market developments, and can also be considered a proxy for commercial real estate returns. In order to verify how well residential real estate prices track commercial real estate prices changes, we calculated the correlation coefficients between the annual growth rates of the commercial and the residential real estate prices for five developed countries for which both data series are available<sup>1</sup>. In all five cases, the correlation coefficients are quite high and significant at 1 per cent significance level. In addition, the empirical study done by He and Webb (2000) provides evidence of unidirectional causality of residential to commercial real estate prices. Furthermore, the study suggests that residential and commercial real estate markets have similar responses to important economic news.

In addition to being a dual proxy, another benefit of using residential real estate prices is that it enables us to examine the interaction patterns of real estate and equity returns in emerging countries, as the data on commercial real estate returns were unavailable to us. A drawback of using residential real estate series is that any recommendation based on this analysis regarding the composition of the portfolio which includes both stocks and commercial real estate securities should be made with due caution. Namely, although these two asset classes are usually highly correlated and subject to the same systemic factors, some divergence between the two series undoubtedly arise, especially in the short run. Another drawback is that due to the usage of residential real estate prices, our analysis is limited to series in quarterly frequencies, as most of the countries do not collect residential real estate data on more frequent basis.

#### 4. Research Methodology

The threshold model with an exogenous variable suggests that real estate price (equity price) changes affect equity price (real estate price) changes differently below a possible threshold than above the threshold. The interaction between the real estate and the equity price changes suggests that there might be a level of returns for one of the variables that acts as a tipping point between the two regimes in equity and/or real estate returns. A possible regime switching model might be assessed using the ordinary least squares

1 Unfortunately, commercial real estate price data for emerging countries were unavailable to us, so we used the data for Denmark, Hong Kong, Switzerland, Singapore and the USA to demonstrate the correlation between the two series.

threshold regressive model (Enders 2004), since it sets a type of adjustment mechanism that corresponds to the state of the economic system<sup>2</sup>.

For each country  $j$ , we consider the following two specifications:

$$\begin{aligned} pprice_{j,t} &= I_{t-d} \left[ \alpha_{j,0,1} + \sum_{i=0}^k \alpha_{j,1,i} eprice_{j,t-i} \right] + (1 - I_{t-d}) \left[ \alpha_{j,0,2} + \sum_{i=0}^k \alpha_{j,2,i} eprice_{j,t-i} \right] + \varepsilon_{1,j,t} \\ eprice_{j,t} &= I_{t-d} \left[ \beta_{j,0,1} + \sum_{i=0}^k \beta_{j,1,i} pprice_{j,t-i} \right] + (1 - I_{t-d}) \left[ \beta_{j,0,2} + \sum_{i=0}^k \beta_{j,2,i} pprice_{j,t-i} \right] + \varepsilon_{2,j,t} \\ j &= 1, \dots, 8, \quad t = 1, \dots, T_j, \end{aligned} \quad (1)$$

where  $pprice$  is the real estate returns series,  $eprice$  is the equity returns series,  $d$  is the delay parameter,  $k$  is the lag length,  $T$  is the length of the data series available for each of the country  $j$  and  $I_t$  is the Heaviside indicator function for the TAR model such that

$$I_t = \begin{cases} 1 & \text{if } x_t \geq \tau \\ 0 & \text{if } x_t < \tau \end{cases},$$

$x$  being the independent variable in the corresponding country specification equation ( $eprice$  or  $pprice$ ) and  $\tau$  is the value of the threshold. ( $\varepsilon_{1t}$ ) and ( $\varepsilon_{2t}$ ) are sequences of independent and identically distributed normal random variables with mean zero and a constant variance. Given that we are working with quarterly data, the maximum size of the delay parameter  $d$  and lag length  $k$  is set to four. The value of the threshold  $\tau$  is unknown and must be estimated along with the other parameters of the TAR model. Because of that, the highest and the lowest 10 per cent of the values are excluded from the search to ensure an adequate number of observations on each side of the threshold. In order to estimate the model parameters along with the threshold value and the delay parameter for each of the specification in equation (1), we follow the Chan (1993) grid-search approach for the threshold selection process, and the Enders (2004) approach for selecting the delay parameter.

Since the threshold is unknown and needs to be estimated along with the parameters of the model, the standard F-test for testing threshold behavior is not appropriate and a different method must be used (Enders, 2004). We perform supremum tests and adopt the Hansen (1997) bootstrapping procedure to obtain the appropriate critical values. We calculate the following F-statistic

$$F = \frac{(SSR_r - SSR_u) / n}{(SSR_u / (T - 2n))}, \quad (2)$$

where  $T$  denotes usable observations,  $SSR_u$  and  $SSR_r$  denote the sum of squared residuals of the unrestricted and the restricted model respectively, where the restricted model is obtained by restricting the model to be linear, namely imposing ( $\alpha_{01} = \alpha_{01}$ ,  $\alpha_{1i} = \alpha_{2i}$ ) or ( $\beta_{01} = \alpha_{01}$ ,  $\beta_{1i} = \beta_{2i}$ ) in the appropriate equation (1) specification and setting  $n$  to the number of parameters estimated in the linear version of the model.

2 We must note that the number of observation available for countries in our sample is somewhat limited. This is especially true for Slovenia, and to the lesser extent Hungary and Russia (for the number of observations please refer to Table 1). This situation often arises when modelling quarterly or annual data for emerging European countries in time series framework. Thus, when discussing the results, one always has to keep in mind that adding new observations to the model, may affect the reliability of the empirical analysis and the results obtained from the analysis.



Since in the Hansen's bootstrapping method the sample value of  $F$  cannot be compared to the standard critical values of the distribution, the following procedure is repeated 10,000 times:

1. For each country  $j, j = 1, \dots, 8$ , we estimate the regression model

$$e_{j,t} = I_{t-d} \left[ \alpha_{j,0,1} + \sum_{i=0}^k \alpha_{j,1,i} x_{j,t-i} \right] + (1 - I_{t-d}) \left[ \alpha_{j,0,2} + \sum_{i=0}^k \alpha_{j,2,i} x_{j,t-i} \right] + \mu_{1,j,t}, \quad (3)$$

$$j = 1, \dots, 8, \quad t = 1, \dots, T_j,$$

Where  $e_t$  is the set of  $T_j$  normally distributed random numbers with mean zero and unit variance and  $x_t$  is the independent variable (*pprice* or *eprice*) of the corresponding TAR model in (1).

2. For the estimated model in step 1, we calculate the statistic

$$F^* = \frac{(SSR_r^* - SSR_u^*) / n}{(SSR_u^* / (T - 2n))},$$

Where  $T$  denotes usable observations like before,  $SSR_r^*$  and  $SSR_u^*$  denote the sum of squared residuals of the unrestricted and the restricted model (3) respectively and the restricted model is obtained from restricting the model (3) to be linear.

3. Finally, from the obtained values  $F_1^*, \dots, F_{10000}^*$ , we calculate the 95<sup>th</sup> percentile for  $F^*$ . If the value of  $F$  from step 2 exceeds the 95<sup>th</sup> percentile for  $F^*$ , we reject the null hypothesis of linearity at the 5 per cent significance level.

If the null hypothesis of linearity cannot be rejected, this suggests that the short run interaction between equity and real estate prices is not non-linear, and also not subjected to regime switching. In that case model (1) collapses into a more general form of a linear model (4), which one would thereafter use for estimating the relationship between equity and real estate prices.

$$pprice_{j,t} = \alpha_{j,0,1} + \sum_{i=0}^k \alpha_{j,1,i} eprice_{j,t-i} + \varepsilon_{1,j,t}$$

$$eprice_{j,t} = \beta_{j,0,1} + \sum_{i=0}^k \beta_{j,1,i} pprice_{j,t-i} + \varepsilon_{2,j,t} \quad (4)$$

$$j = 1, \dots, 8, \quad t = 1, \dots, T_j,$$

## 5. Results

Table 2 displays the estimates of the threshold, delay parameter, and lag length obtained by implementing Chan's (1993) algorithm, along with the values of supremum F-test and the corresponding bootstrap critical value for 95th percentile necessary for pretesting the TAR model. When comparing the values of F statistics with the corresponding critical value, one must note that all countries in the sample exhibit regime switching behaviour of asset prices in at least in one direction. TAR models of equity returns for all countries in the sample suggest the equity returns are affected by regime switching behaviour of real estate returns, thus confirming the presence of the credit-price effect. On the other hand, since the value of F-statistics does not exceed bootstrap critical value in TAR models of real estate prices for Croatia, Hungary, and Russia, one can claim that in those countries the wealth effect is not effective as the real estate returns are not affected by regime switching behaviour of equity



returns in the short run. We can thus conclude that in general equity returns in Central and Southeastern European countries seem to be quite responsive to real estate returns changes, while the reaction of real estate returns to changes in equity returns is less frequent, and (as we will show in the subsequent section) much more subdued.

As far as the values of estimated thresholds are concerned, they are often found to be quite large and predominantly negative. In TAR models of equity prices, the threshold value separating two distinct real estate returns regimes is negative in 7 out of 8 cases. This suggests that equity prices in all countries except the Czech Republic react differently to large negative real estate price changes when compared to small negative and/or positive changes. The same applies for the reaction of real estate returns to changes in equity returns. Namely, in TAR models of real estate returns, the estimated threshold value is negative in 3 out of 5 countries with confirmed threshold effects.

**Table 2 | Estimates of the TAR Model Parameters, Supremum F-statistics and Bootstrap Critical Value**

Country	Dependent variable: equity returns Explanatory variable: real estate returns						Dependent variable: real estate returns Explanatory variable: equity returns					
	$\tau$	d	k	AIC	F- statistics	Bootstrap F*	$\tau$	d	k	AIC	F- statistics	Bootstrap F*
Bulgaria	-3.6	0	1	386	11.94*	2.87	18.2	4	4	252	3.67*	2.42
Croatia	-1.1	1	3	456	2.45*	2.40	16.8	0	0	364	2.12	3.10
Czech Republic	2.9	1	2	449	2.72*	2.57	-13.6	1	2	319	5.75*	2.58
Estonia	-10.4	2	4	520	4.84*	2.35	-16.6	0	2	494	3.75*	2.55
Hungary	1.1	0	4	318	3.41*	2.12	-10.1	0	0	182	2.28	3.24
Lithuania	-5.8	1	4	408	5.09*	2.39	-11.4	3	3	340	4.92*	2.52
Russia	-3.0	0	1	357	5.65*	2.82	8.1	0	1	280	0.38	2.89
Slovenia	-0.4	2	2	243	6.51*	2.67	6.1	2	4	146	4.91*	2.63

Note: Bootstrap F\* bootstrap critical value of supremum F-test; \* significant at 5 per cent significance level.

Source: Calculation of the authors

The comparison between the estimates of the delay parameter and lag length for equity price and real estate price models also provides interesting findings. Namely, both the delay parameter and lag length for equity price TAR model are considerably smaller when compared to their counterparts in real estate TAR models with confirmed threshold effects. This difference in magnitude is especially noticeable for delay parameters, which in turn indicates that equity returns incorporate regime switches in real estate returns more swiftly. On the other hand, the reaction of real estate returns to regime switches in equity returns is much slower and delayed. Also, equity price changes require a longer time interval in order to fully transmit its effects to real estate prices.

**Table 3 | Characteristics of the TAR Model Regimes**

Country	Dependent variable: equity returns Explanatory variable: real estate returns						Dependent variable: real estate returns Explanatory variable: equity returns					
	$\tau$	$\alpha_{j,1,i}$	$\alpha_{j,2,i}$	Joint F-test	F(l <sub>t-d</sub> )-test	F(1-l <sub>t-d</sub> )-test	$\tau$	$\alpha_{j,1,i}$	$\alpha_{j,2,i}$	Joint F-test	F(l <sub>t-d</sub> )-test	F(1-l <sub>t-d</sub> )-test
<b>Bulgaria</b>	-3.6	1.95	-8.97	12.5 [0.00]	3.14 [0.05]	21.90 [0.00]	18.2	0.43	0.07, 0.08, 0.07	12.2 [0.00]	4.43 [0.004]	15.1 [0.00]
<b>Croatia</b>	-1.1	2.05, 1.39, 1.36	–	2.42 [0.03]	4.91 [0.002]	0.54 [0.70]	–	–	–	–	–	–
<b>Czech Republic</b>	2.9	–	–	2.45 [0.03]	1.04 [0.38]	4.52 [0.007]	-13.6	–	0.32	3.69 [0.003]	1.68 [0.18]	4.80 [0.005]
<b>Estonia</b>	-10.4	0.58	0.90, -0.76	4.02 [0.00]	5.57 [0.0004]	3.25 [0.01]	-16.6	0.22	0.22, 0.53	4.58 [0.00]	3.62 [0.02]	4.58 [0.007]
<b>Hungary</b>	-1.1	14.89	–	2.97 [0.01]	4.46 [0.004]	1.99 [0.11]	–	–	–	–	–	–
<b>Lithuania</b>	-5.8	–	6.19, 3.76, -8.55	3.63 [0.002]	1.06 [0.39]	6.90 [0.0002]	-11.4	–	2.81, 1.02	4.58 [0.00]	1.14 [0.35]	4.12 [0.008]
<b>Russia</b>	-3.0	–	-8.45	3.46 [0.01]	0.27 [0.75]	7.54 [0.002]	–	–	–	–	–	–
<b>Slovenia</b>	-0.4	1.46, 1.36	8.09	8.55 [0.00]	10.1 [0.0001]	8.05 [0.0006]	6.1	-0.59	0.10, 0.12	8.21 [0.00]	6.40 [0.001]	8.23 [0.0003]

Note:  $\alpha_{j,1,i}$  – statistically significant coefficients of the individual lags of explanatory variables in the first regime;  $\alpha_{j,2,i}$  – statistically significant coefficients of the individual lags of explanatory variables in the second regime; F-test - the test of joint significance of all the variables in the TAR model; F(lt-d)-test - block exclusion test of all the lags of the explanatory variable within the first regime; F(1-lt-d)-test - block exclusion test of all the lags of the explanatory variable within the first regime.

Table 3 presents the output of individual TAR regressions for countries and models with confirmed TAR effects. Along with the  $\tau$  threshold values and the F-test of joint significance of TAR regressions, the table also presents block exclusion test results for all lags of the explanatory variable in individual regimes and estimates of statistically significant coefficients of the lags of the explanatory variable in individual regimes ( $\alpha_{j,1,i}$  and  $\alpha_{j,2,i}$ ). Both the block exclusion tests and the individual coefficient estimates of explanatory variables enable us to assess the strength of influence of individual real estate returns (equity returns) regime on equity returns changes (real estate returns changes).

All the TAR regression models appear jointly statistically significant, as suggested by the joint F-test values and the corresponding p-values. Although the block exclusion tests of individual regimes reveal that the short-run interactions between the real estate and the equity returns vary significantly across countries, some common features nevertheless emerge. The results of the equity price TAR models suggest that in Bulgaria, Estonia, and Slovenia the changes of real estate returns confined within both regimes influence the equity returns. Individual estimates of explanatory variables imply that in those cases the second regime influences equity returns much stronger than the first regime, which in turn

means that equity returns react more strongly to large and negative real estate price changes when compared to other type of real estate price changes. On the other hand, in Croatia and Hungary only the first real estate returns regime is significant. Due to the fact that at the same time threshold values for both countries are negative, we can conclude that in Croatia and Hungary large negative real estate price changes are not transmitted to equity returns, while all other types of changes (small negative and positive changes) are transmitted. Finally, in the case of the Czech Republic, Lithuania, and Russia, the second regime is the only statistically significant regime, which suggests that in those countries only large negative real estate price changes have an impact on equity returns. We can deduce from this discussion that in all countries except Croatia and Hungary equity returns react either exclusively or more strongly to large negative real estate price changes.

Similar conclusions can be drawn from the real estate price TAR models, although one must note that the size of the coefficients in the real estate price models is much smaller, suggesting that the real estate returns in general are much less sensitive to equity returns changes in the short-run. In three out of five countries with confirmed regime switching behavior (Bulgaria, Estonia, and Slovenia) both equity returns regimes are significant, while in remaining countries (the Czech Republic and Lithuania) only the second regime is significant. When comparing the size of the estimates of the significant equity price lags from the both regimes across countries, one cannot draw a general conclusion about which equity price changes are transmitted more completely to real estate returns. This means that the threshold effects in the reaction of real estate prices to changes in equity prices are country-specific, which is different when compared to the reactions of equity returns to real estate price changes in majority of countries, where large and negative changes affect equity returns more strongly when compared to the other types of real estate price changes.

One must also note that in countries where both credit-price and wealth effect are present (*i.e.* the observed regime switching behavior is bidirectional), the threshold interaction patterns are the same. In other words, in Bulgaria, Estonia, and Slovenia, real estate (equity returns) react to changes in equity prices (real estate prices) within both regimes. On the other hand, in the Czech Republic and Lithuania, only the second regime which contains large negative changes of real estate and equity returns is effective. This finding suggests that in the Czech Republic and Lithuania credit-price and wealth effect only manifest if either real estate price or equity price changes are large and negative.

## 6. Concluding Remarks

This research clearly demonstrates that the analysis of the short-run interactions between equity prices and real estate prices within a linear framework may result in misleading conclusions. Using the TAR model, supremum F-test, and bootstrap critical values we show that one can reject the null hypothesis of a linear relationship between those two asset classes in favour of the threshold alternative for all 8 emerging countries examined in this paper. This research also shows that the interaction between these two asset classes is not continuous or constant throughout time. Namely, when examining the significance of individual regimes, it becomes obvious that in many cases equity returns (real estate returns) react to changes in real estate returns (equity returns) only during one regime - either before or after real estate returns (equity returns) reach a certain threshold value. The estimation results of the equity returns TAR models for all countries in the sample suggest that equity returns are affected by regime switching behaviour of real estate returns, thus confirming

the presence of the credit-price effect in all examined emerging economies. On the other hand, since the value of F-statistics does not exceed bootstrap critical value in TAR models of real estate returns for Croatia, Hungary, and Russia, in those countries the wealth effect does not appear to be effective, as the real estate returns are responding to regime switching behavior of equity returns. In other five countries (Bulgaria, the Czech Republic, Estonia, Lithuania, and Slovenia) we find evidence of a small wealth effect. We can thus conclude that in general equity returns in central and Southeastern European countries seem to be quite responsive to real estate returns changes, while the reaction of real estate returns to changes in equity returns is less frequent, and much more subdued.

The threshold value itself, which separates two regimes, is often found to be quite large and predominantly negative, thus emphasizing the importance of major negative shocks on asset markets in the price discovery process. In the equity returns TAR models, threshold values are negative in 7 out of 8 cases, suggesting that equity returns in the majority of the countries react differently to large negative real estate returns changes when compared to small negative and/or positive changes. Since the threshold value is negative in 3 out of 5 countries in the real estate returns TAR models, the same conclusion can be drawn for the reaction of real estate returns to changes in the equity returns in the Czech Republic, Estonia, and Lithuania. The results of the block exclusion tests and the individual estimates of significant lags of explanatory variables within the individual regimes take us one step further and enable us to conclude that in the majority of examined emerging countries equity returns react more strongly to large negative real estate returns changes, when compared to real estate returns changes of different magnitude, and alternative sign. However, we cannot draw any general conclusions about the reactions of real estate returns, since their responses to equity returns regimes are much less homogeneous across the countries.

As our findings indicate that equity returns and real estate returns do interact in the short-run in the all central and Southeastern European countries under examination, we must conclude that the potential for portfolio diversification within individual countries in the short-run is somewhat limited. Due to the fact that this interaction is ingrained within individual real estate and equity returns regimes and is often country-specific, the construction of an optimal portfolio that includes both equities and real estate securities should take these country-specific interaction characteristics into account.

Our findings also have implications for policy makers in emerging European countries. As equity returns in these countries react more strongly to large negative real estate returns changes, when compared to real estate returns changes of different magnitude, the policymakers should pay special attention to the developments in the real estate markets. This is especially important if real estate boom is in progress, and one suspects of a real estate price bubble. If real estate prices are indeed misaligned with the fundamentals, and there is a potential for real estate market crash, the economic effects of that crash in emerging European countries under examination will be aggravated by the stock market correction that will follow after the real estate market correction. As these developments can jeopardize macroeconomic and financial stability of a country, economic policy mix should aim at precluding real estate bubbles from taking place.

One must note that the empirical analysis in this paper was conducted on country-by-country basis, which means that we only established the limited potential for portfolio diversification within individual emerging countries. This analysis thus does not offer any findings related to international portfolio diversification. Country selection often appears to

be the key performance component in this regard, with the choice often depending on the degree of the risk aversion of an investor. One must also note that although our research does include the 2008 global financial crisis into analysis, we do not control specifically for its effects in our TAR models of equity and real estate returns. The events related to the crisis may have contributed to the statistical significance of large negative returns in the interaction between real estate and asset prices that was repeatedly found in this study. One may also assume that the interaction between real estate and equity returns has weakened in the aftermath of the crisis as a result of increased segmentation of asset markets worldwide. In time, as more data becomes available, we will be able to test that hypothesis empirically.

## Appendix

**Table A1 | Data Description and Sources**

Country	Data range	Real estate returns	Equity returns
<b>Bulgaria</b>	2000Q4–2012Q2	Flats, existing, big cities, BIS	Sofia Stock Exchange index, Eurostat
<b>Croatia</b>	1998Q1–2012Q1	All types of dwellings, new and existing, Croatian National Bank	Crobex index, Bloomberg
<b>Czech Republic</b>	1998Q1–2012Q1	Single family houses and flats, BIS	Prague Stock Exchange 50 Index, Eurostat
<b>Estonia</b>	1997Q1–2012Q1	All types of dwellings, new and existing, BIS	Tallinn Stock Exchange index, Eurostat
<b>Hungary</b>	2001Q4–2012Q2	All types of dwellings, existing, BIS	Budapest Stock index, Eurostat
<b>Lithuania</b>	2000Q1–2012Q2	All types of dwellings, new and existing, BIS	Vilnius Stock Exchange Index, Eurostat
<b>Russia</b>	2001Q1–2012Q1	All types of dwellings, existing, BIS	INDEXCF Index, Bloomberg, Eurostat
<b>Slovenia</b>	2003Q1–2011Q4	All types of dwellings, new and existing, BIS	Slovenski Borzni Index, Bloomberg

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