3. A NON-LINEAR MODEL OF CAUSALITY BETWEEN THE STOCK AND REAL ESTATE MARKETS OF EUROPEAN COUNTRIES

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Abstract

Using the threshold auto-regressive (TAR) model, we set out in this study to determine whether any long-run equilibrium relationship exists between the stock and real estate markets of the European countries, with our empirical results revealing that such a long-term relationship does indeed exist under a specific threshold value. We go on to adopt the threshold error-correction model (TECM) to determine whether a similar relationship is discernible between two specific variables and any non-linear forms. The findings clearly point to the existence of long-run unidirectional and bidirectional causality between the real estate market and the stock market in regions both above and below the threshold level. Finally, we find the existence of both wealth and credit price effects in the real estate markets and stock markets of European countries, again both above and below the threshold value, which thereby offers a better interpretation of the meaning of the macroeconomic factors.

Keywords: causality, threshold model, threshold error-correction model (TECM), wealth effect, credit price effect

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1. Introduction

It has been clearly demonstrated in the previous literature that any attempt at precisely determining the relationship between the stock market and the real estate

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market remains somewhat contentious; and indeed, regardless of whether this relationship is examined over the short-term or the long-term, it remains unsettled as to whether the two markets are segmented or integrated.

In most of the early studies exploring this issue, the tendency was to adopt linear models as the means of determining the existence of such segmentation or integration, with these studies typically using the 'capital asset pricing model' (CAPM) as their initial starting point; for example, based upon such a model, Jorion and Schwartz (1986) conclude that segmentation influences asset pricing. Liu *et al.,* (1990) also follow a similar framework in an attempt to clarify the issue further, exploring whether the commercial non-farm real estate market is integrated with, or segmented from, the stock market. Their evidence provides support for the hypothesis that segmentation does exist, albeit based upon indirect barriers such as the cost, amount and quality of information on real estate, as opposed to any legal constraints.

Using a cross-sectional regression analysis of real estate price indices and stock price data on seventeen countries, Quan and Titman (1997) examine the relationship between real estate stock portfolio returns and standard appraisal-based index returns; their results indicate a significantly positive relationship between both real estate valuations and stock returns. Liu *et al.,* (1990) find further evidence of market segmentation between the real estate market and the stock market, with their results gaining additional support from the findings of Geltner (1990), who reported discernible differences between the noise component of stock and real estate returns, and thereby concluded that the two markets are probably segmented.

In contrast, however, Gyourko and Keim (1992) report totally contradictory findings, with their results providing evidence to suggest that the stock market contains important information on real estate fundamentals and that S&P 500 returns have significant explanatory power in terms of predicting equity 'real estate investment trust' (REIT) returns. Furthermore, Meyer and Webb (1993) also note that the returns on equity REITs appear to be very similar to the returns on common stocks, thereby suggesting a certain degree of integration between the two markets.

There may well be differences in the initial perspectives of the prior studies which, along with the different models and methodologies adopted, may lead to different empirical results being obtained, and therefore, quite diverse conclusions. It is also worth noting, however, that in many of the prior studies, both the real estate market and the stock market are assumed to exhibit linear behavior, despite the fact that there is growing recognition of the non-linear characteristics of the economic variables.

Given that both segmentation and integration have been reported, the fact that the majority of the studies within the prior literature have tended to ignore the possibility that the relationship between the real estate market and stock market could be non-linear may well be the main reason for these different outcomes.[4] A number of the prior studies also suggest that many of the macroeconomic and financial time-series

[4] *Examples include: Schnare and Struyk (1976), Goodman (1978) and Richardson and Thalheimer (1982).*

variables, including stock price, are organized by stochastic trends; thus, there is some general recognition that non-linear models are capable of fitting the data.[5]

Liu *et al.,* (1990) suggest that the securitized real estate indices, such as REITs, behave very much like common stocks, exhibiting non-linear behavior; they also note that equity REITs are integrated with the stock market. Thus, the research focus is clearly shifting towards the possibility of non-linearity in both stock price and real estate price data; and indeed, based upon their use of non-linear models, both Liu and Mei (1992) and Ambrose *et al.,* (1992) claim that the real estate and stock markets are indeed integrated, with the latter of these two studies using rescaled range analysis – developed within the fractal geometry literature – to test for non-linear trends in the returns series for different asset classes.

A fractional test is developed by Okunev and Wilson (1997), which allows for a stochastic trend term, as opposed to a deterministic drift term, and which attempts to resolve the issue of why the prior studies have continually obtained such diverse results relating to the integration or segmentation of the stock and real estate markets. Wilson and Okunev (1999) subsequently went on to use fractional cointegration in an attempt to identify the long-term equilibrium between the stock and property markets in the US, the UK and Australia, with their results showing no evidence of any integration between the two markets in either the US or the UK, although some of their findings revealed some long-term co-memory effects within the Australian markets.

Wilson *et al.,* (1996) explore the relationship between the stock and real estate markets by comparing the results of the non-linear model with those obtained through the use of the conventional Engle and Granger (1987) cointegration tests. Although the non-linear model supports the notion that the markets are fractionally integrated, the cointegration results also provide contradictory support for the view that the stock and real estate markets are segmented.

Studies within the extant literature examining the relationship between the stock and real estate markets are plentiful, with several of these studies having found that the process of adjustment towards equilibrium between these markets is asymmetric;[6] this asymmetric phenomenon is revealed in the results of these studies through the different price transmissions between the real estate and stock markets. As a result, two mechanisms are proposed within the prior literature for the interpretation of the relationship between these markets. The first of these is the well-known 'wealth effect', which indicates that the stock market is capable of influencing the real estate market. As noted by Markowitz (1952), high-income households, which are inherently more likely to hold substantial stock, will invariably have a desire to rebalance their portfolios in response to changes in stock prices, whilst Ando and Modigliani (1963) propose that households with unanticipated gains in share prices will tend to increase the amount of housing stock across their lifecycle.

The second contrasting theoretical interpretation of the relationship between the two markets is the 'credit price effect', which claims that the real estate market actually

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[5] *See, for example, Lee and Jeon (1995).*

[6] *Examples include: Myer and Webb (1993), Okunev and Wilson (1997), Quan and Titman (1999) and Kapopoulos and Siokis (2005).*

influences the stock market. Both Phang (2004) and Edelstin and Lum (2004) find that public housing wealth has a significant effect on household consumption, whilst Chen (2001) reveals that, with a rise in the price of real estate, a firm which holds a certain amount of real estate or land accrues huge unrealized capital gains. Thus, the future revenue from its expanded investment will lead stockholders to bid up the equity value of that particular firm.

The massive fluctuations that are discernible in European asset prices have often been considered to be a boom and subsequent bursting of the bubble (boom and bust cycle); however, in the second half of the current decade, a much bigger boom-bust cycle has been experienced by the asset markets of Europe (primarily the stock and real estate markets) than by any other sector of the economy. Not only do these tremendous shifts in asset prices have a huge impact on the net worth of property assets, but they also have significant and persistent effects on real economic activities. Such major fluctuations may come about through relatively infrequent, but nevertheless important events, notably oil shocks or changes in fiscal and other policy regimes, with such events ultimately affecting the macro- and micro-economic performance of a country, and also changing the very nature of its economic relationships.

Perron (1989) concludes that business cycles are in fact transitory fluctuations around a more or less stable trend path, thereby resulting in non-linear phenomena. In similar fashion, we argue that a non-linear relationship may exist within European countries. Furthermore, we note that in the majority of the prior empirical studies addressing the issue of equilibrium, most of the models fail to take into consideration the asymmetric properties of the adjustment process in both the real estate market and the stock market.

Conventional cointegration methods are inappropriate, essentially because they assume a unit as the null hypothesis, and a linear process under the alternative; hence, Enders and Granger (1998) and Enders and Siklos (2001) propose the use of the asymmetric ‘threshold auto-regressive (TAR) model and the ‘momentum-threshold auto-regressive (M-TAR) cointegration tests, indicating that the application of non-linear models using macroeconomic variables is likely to become the mainstream methodology. These models are equipped to provide the requisite empirical evidence favorable to the elucidation of long-run relationships through the use of error correction mechanisms or by permitting asymmetric adjustment.

Needless to say, there are several other non-linear candidate models which might also be capable of explaining the evolution of the behavior of the variables; however, the testing framework used here has the added advantage that it preserves the preferred linear long-run (or cointegrating) relationship in the existing theoretical framework, whilst also permitting threshold adjustment in the error correction terms. The momentum framework is also appealing from an economic perspective, since the relevant tests have demonstrably more power than conventional threshold adjustment models. Most importantly, since the asymmetry investigated in this study is a fairly commonplace form in financial time-series analysis, the proposed technique is simple to implement whilst also being extremely practical.

Given that the economic variables are all non-linear variables, Caner and Hansen (2001) also suggest the use of the M-TAR specification. As compared to the conventional cointegration approaches, M-TAR produces more convincing evidence, essentially because it has sufficient flexibility that enables it to capture non-linear adjustment patterns. Our primary objective in this study is to ascertain whether there is indeed any significant relationship between the real estate and stock markets in European countries using a non-linear model. We aim to facilitate the forecasting of future performance between one market and the other, thereby providing important and significant insights for investors and speculators.

There are, therefore, several important issues that are of particular interest to this study. Firstly, using the threshold method of Enders and Grander (1998) and Enger and Siklos (2001), we aim to determine whether any non-linear forms are found to exist. Secondly, our results should facilitate an investigation into the causal relationships between the real estate markets and stock markets of European countries. Finally, Granger causality will enable us to determine whether the 'wealth effect' or the 'credit price effect' exists within any of the European countries that are either above or below the threshold.

The remainder of this study is organized as follows. A description of the methodology adopted for this study is provided in Section 2. This is followed in Section 3 by the presentation of our empirical results. Finally, the conclusions drawn from this study are presented in Section 4.

2. Methodology

2.1 Threshold Cointegration Test

In this study, we employ the threshold cointegration technique advanced by Enders and Siklos (2001) to test long-run relationship between real estate market and stock market with asymmetric adjustment in European countries. This test involves a two-stage process. In the first stage, we estimate the long-run equilibrium relationship of the form:

$$x_{1t} = \beta_0 + \beta_1 x_{2t} + k_t \tag{1}$$

where: x_{1t} and x_{2t} are stock price index and real estate price index; and k_t is the stochastic disturbance term. The second stage focuses on the OLS estimates of ρ_1 and ρ_2 in the following regression:

$$\Delta k_t = h_t \rho_1 k_{t-1} + (1 - h_t)\rho_2 k_{t-1} + \varepsilon_t \tag{2}$$

where: ε_t is a white-noise disturbance; the residuals, Δk_t in Equation (1) is extracted to Equation (2) for further estimation; and h_t is the Heaviside indicator function such that:

$$h_t = \begin{cases} 1 & \text{if} \quad k_{t-1} \geq \psi \\ 0 & \text{if} \quad k_{t-1} < \psi \end{cases} \tag{3}$$

where: ψ is the threshold value. In order for $\{k_{t-1}\}$ to be stationary, a necessary condition is –2 < (ρ_1, ρ_2) < 0. If the variance of ε_t is sufficiently large, it is also possible for one value of ρ_j to be in the range of between –2 and 0. The model using Equation (2) is referred to as the 'threshold autoregression' (TAR) model, where the test for the threshold behavior of the equilibrium error is termed the 'threshold cointegration test'. If the value of k_t is above ψ, then the adjustment is $\rho_1 k_{t-1}$, and if the value of k_t is below ψ, then the adjustment is $\rho_2 k_{t-1}$. The null hypothesis of $\rho_1 = \rho_2 = 0$ tests for the cointegration relationship, with the rejection of the null hypothesis indicating the existence of cointegration between the variables. When the adjustment process is serially correlated, Equation (2) is re-written as:

$$\Delta k_t = h_t \rho_1 k_{t-1} + (1 - h_t)\rho_2 k_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta k_{t-i} + \varepsilon_t \tag{4}$$

Instead of estimating Equation (2) with the Heaviside indicator depending on the level of k_{t-1}, the decay could also be allowed depending on the previous period's change in. In this case, the Heavisde indicator of Equation (3) becomes

$$h_t = \begin{cases} 1 & \textit{if} \;\; \Delta k_{t-1} \geq \psi \\ 0 & \textit{if} \;\; \Delta k_{t-1} < \psi \end{cases} \tag{5}$$

Furthermore, the Heaviside indicator could then be specified as $h_t=1$ if $\Delta k_{t-1} \geq \psi$ and $h_t=0$ if $\Delta k_{t-1} \leq \psi$. This model is termed the 'momentum-threshold autoregression' (M-TAR) model. Where positive deviations are more prolonged than negative deviations, the TAR model can capture a 'deep' cycle process. As such, the M-TAR model representation is capable of capturing 'sharp' movements within a sequence. A consistent estimate of the threshold, ψ, can be obtained by adopting the methodology of Chan (1993) to minimize the residual sum of the squares from the fitted model. The threshold parameter ψ, which is restricted to the ranges of the remaining 70% of k_t when the largest and smallest 15% values are discarded, is selected as an unknown value. Since there is no general presumption as to whether it is better to use either the TAR or M-TAR model, the recommendation of this study is to select adjustment mechanism based upon the 'Akaike information criterion' (AIC) and the 'Schwartz Bayesian information criterion' (SBC).

2.2 Granger-Causality Results Based on the Threshold Error-Correction Model (TECM)

Given the threshold cointegration found in previous section, we advanced to test the transmissions using threshold error-correction model (TECM). The TECM can be presented as follows (Enders and Granger, 1998; Enders and Siklos, 2001):

$$\Delta Y_{it} = \alpha + \rho_1 Z^{+}_{t-1} + \rho_2 Z^{-}_{t-1} + \sum_{i=1}^{n_1} \delta_i \Delta lres_{t-i} + \sum_{i=1}^{n_2} \theta_i \Delta lstk_{t-i} + \varepsilon_t \tag{6}$$

where: $Y_{it} = (lstk_t,\ lres_t)$, $lstk_t$ and $lres_t$ denotes the natural logarithm of the stock price and the real estate price index. $Z^{+}_{t-1} = h_t \hat{k}_{t-1},\ Z^{-}_{t-1} = (1-h_t)\hat{k}_{t-1}$ such that $h_t = 1$ if $k_{t-1} \geq \psi$, $h_t = 0$ if $k_{t-1} < \psi$ and ε_t is a white-noise disturbance. Through the system, the Granger-Causality tests are examined by testing whether all the coefficients of $\Delta lres_{t-i}$ and $\Delta lstk_{t-i}$ are statistically different from zero based on a standard *F*-test and if the ρ_j coefficients of the error-correction are also significant. Granger-Causality tests are very sensitive to the selection of lag length, we determine the appropriate lag lengths use AIC criterion.

3. Empirical Results

The data used in this study comprises of monthly observations on the natural logarithm of the real estate price indices (*lres*) and the natural logarithm of the stock prices (*lstk*) between January 2000 and January 2007. The real estate price indices and the stock price indices are collected from the Institute for Physical Planning and Information database, and the DATASTREAM database.

3.1 Threshold Cointegration Tests

Based upon the prior findings, that the stock price and real estate price indices are considered to be integrated of the same first order, *I*(1), we proceed with a further test of the long-run equilibrium relationship between these two variables, employing the threshold cointegration test on the strength of such non-linearity. Equation (1) is estimated using the ordinary least squares (OLS) method with the residuals being saved in the sequence $\{k_t\}$. For each type of asymmetry, we set the indicator function h_t according to Equation (3) or Equation (5), and then estimate Equation (4).

The '***Akaike information criterion' (***AIC) and 'Schwartz-Bayesian criterion' (SBC) are used to select the most appropriate lag length and also to determine whether the adjustment mechanism is best captured as a TAR or M-TAR process. Widespread support is found for the method adopted by Chan (1993), who obtained consistent threshold estimates using the M-TAR model, as shown in Table 1.

Table 1

The results of cointegration tests

Country	Model	lags	ψ	ρ_1[5]	ρ_2[6]	AIC/SBC[1]	$\rho_1 = \rho_2 = 0$[2]	$\rho_1 = \rho_2$[3]	Q(12)[4]
Netherlands	MTAR	3	-0.115	-0.021	-0.554***	-94.795	7.103**	12.593***	10.684
				(-0.754)	(-3.725)	-82.823			[0.556][9]
Italy	MTAR	1	0.162	-0.038*	-0.229*	-147.445	2.572	1.953	18.314
				(-1.508)	(-1.707)	-140.189			[0.106]

Country	Model	lags	ψ	ρ_1[5]	ρ_2[6]	AIC/SBC[1]	$\rho_1 = \rho_2 = 0$[2]	$\rho_1 = \rho_2$[3]	Q(12)[4]
Spain	MTAR	2	-0.003	-0.055	-0.127*	-149.603	5.770*	9.617***	9.616
				-1.293	(-3.145)	-139.976			[0.649]
U.K.	MTAR	10	-0.122	-0.027	-0.485**	-164.130	5.814*	8.562**	6.300
				(-0.866)	(-3.217)	-136.481			[0.900]
Germany	MTAR	1	0.111	-0.031	-0.061**	-94.074	2.618	0.634	8.049
				(-0.267)	(-2.191)	-86.817			[0.624]
Belgium	MTAR	8	-0.090	-0.018	-0.339***	-142.657	5.876*	9.004***	9.164
				(-0.678)	(-3.323)	-119.350			[0.688]
France	MTAR	3	-0.123	-0.023	-0.396***	-121.771	5.923*	9.318***	11.832
				(-0.927)	(-3.312)	-109.798			[0.459]
Switzerland	MTAR	1	-0.135	-0.026	-0.920**	-164.816	2.965	4.796	9.222
				(-1.098)	(-2.127)	-157.559			[0.683]

*Notes: a. AIC=T*ln(RSS)+2*n ; and SBC=T*ln(RSS)+n*ln(T), where n = number of regressors and T=number of usable observations RSS is the residual sum of squares.*

b. This test follows a non-standard distribution so the test statistics are compared with critical values reported by Enders and Siklos (2001).

c. The numbers reported in this column are F-statistics of symmetric adjustment. The critical values are taken from Enders and Siklos (2001).

d. Q(12) is the Ljung-Box Q-statistic for the joint hypothesis of no serial correlation among the first residuals.

e. Entries in parentheses in this column are the t-statistics for the null hypothesis $\rho_1 = 0$, $\rho_2 = 0$. Critical values are taken from Enders and Granger (1998)

f. Numbers in brackets are p-value.

*g. ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.*

Taking AIC and SBC as the selection standards, we find that the preferred model for our adjustment mechanisms is the M-TAR model, largely as a result of its consistent estimations of the threshold. As one may see in Table 1, based upon the Chan (1993) methodology, the threshold value for the Netherlands is $\psi = -0.115$; thus, the null hypothesis of $\rho_1 = \rho_2 = 0$ is rejected at the 5 per cent significance level.

Evidence is found in this study for the rejection of the null hypothesis of no cointegration for the Netherlands, Spain, the UK, Belgium and France, and the acceptance, at the 10 per cent level, of the alternative hypothesis; however, the results show no long-run relationship between the stock and real estate markets of Italy, Germany and Switzerland. We further test for asymmetric adjustment using the *F*-statistic, with our study also presenting evidence to show that $| \rho_1 | < | \rho_2 |$, which implies that the speed of adjustment is more rapid for positive discrepancies than for negative discrepancies.

Taking, as an example, the Netherlands, the rate converges to its long-run equilibrium, ψ, at the rate of 2.15 per cent for a positive deviation, and 55.48 per cent for a negative deviation. It would therefore seem reasonable to conclude that the long-term equilibrium relationship between the stock market and the real estate market in European countries follows non-linear adjustment; hence, the adjustment mechanisms of the Netherlands, Spain, Belgium, the UK and France are asymmetric.

3.2 Threshold Error-Correction Models (TECM)

If threshold cointegration does exist, an asymmetric error-correction model can be used to investigate the movement of the variables from their long-run equilibrium relationship; we therefore apply asymmetric error-correction models with consistent threshold estimates and present the results in Table 2.

Table 2

Granger-Causality Results Based on the Threshold Error-Correction Model

	Netherlands		Spain		France		Belgium		United Kingdom	
	lres	lstk	lres	lstk	lres	lstk	lres	lstk	lres	lstk
Z_plus_{t-1}	0.015	-0.019	0.003	0.012	0.018	-0.034	0.029*	-0.029	0.089**	-0.024
Z_minus_{t-1}	-0.123	-0.438	0.021	-0.136***	-0.009	-0.414***	0.027	-0.143	0.054	-0.320**
$H_0: \delta_1 = \delta_2 = \ldots = \delta_i = \rho_1 = 0$	0.166		4.4047**		2.838**		2.367**		1.768	
$H_0: \delta_1 = \delta_2 = \ldots = \delta_i = \rho_2 = 0$	0.174		1.444		0.367		1.221		1.437	
$H_0: \theta_1 = \theta_2 = \ldots = \theta_j = \rho_1 = 0$		1.211		0.139		1.856		1.178		2.428*
$H_0: \theta_1 = \theta_2 = \ldots = \theta_j = \rho_2 = 0$		3.171**		6.659***		3.485**		0.643		2.477*
H_0: (Lstk) $\rho_1 = \rho_2$		5.558***		6.234***		5.596***		1.715		3.057**
H_0: (Lres) $\rho_1 = \rho_2$	0.258		5.762***		3.804**		4.810**		4.536**	
Above the threshold	—		Wealth Effect		Wealth Effect		Wealth Effect		Credit Price Effect	
Below the threshold	Credit Price Effect		Credit Price Effect		Credit Price Effect		—		Credit Price Effect	

*Notes: a. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, F statistics are in parentheses.*
b. Lres and Lstk denote the natural logarithm of the real estate price indices and the stock price indices.

In the case of the Netherlands, based upon the threshold cointegration found in the previous section, we test the transmissions using the TECM:

$$\Delta lres_t = \alpha_1 + 0.015 Z_{t-1}^{+} - 0.123 Z_{t-1}^{-} + \sum_{i=1}^{k_1} \delta_i \Delta lres_{t-i} + \sum_{i=1}^{k_2} \theta_i \Delta lstk_{t-i} + \varepsilon_t \qquad (7)$$

$$\Delta lstk_t = \alpha_2 - 0.019 Z_{t-1}^{+} - 0.438 Z_{t-1}^{-} + \sum_{i=1}^{k_1} \delta_i \Delta lres_{t-i} + \sum_{i=1}^{k_2} \theta_i \Delta lstk_{t-i} + \varepsilon_t \qquad (8)$$

The Granger causality tests are examined throughout the system by testing whether all of the coefficients of $\Delta lres_t$ and $\Delta lstk_t$ are statistically different from zero based on a standard *F*-test, and whether the ρ_j coefficients of the error-correction term are also significant, with the appropriate lag lengths being determined using AIC methodology.

Finally, the speed of adjustment for positive (negative) deviations from fundamental value is determined by the estimated coefficients of Z^{+}_{t-1} (Z^{-}_{t-1}).

The results of the Granger causality tests based on the corresponding TECM are presented in Table 2, which clearly shows the credit price effect of the unidirectional causality running from the real estate market to the stock market in the Netherlands and the UK. Within the Netherlands, for example, the empirical results reveal unidirectional causality running from the real estate market to the stock market when the threshold variable is below –0.115 (H_0: $\delta_1 = \delta_2 \ldots = \rho_2 = 0$), thereby rejecting the null hypothesis at the 5 per cent level of significance. As such, these results clearly indicate that the real estate market is influenced by the stock market, thereby revealing the existence of the wealth effect.

In contrast, when the threshold variable is above –0.115, we can find no discernible evidence of any unidirectional causality running from the stock market to the real estate market (H_0: $\theta_1 = \theta_2 = \ldots = \rho_2 = 0$), or indeed, from the real estate market to the stock market; thus, there can be no rejection of the null of hypothesis at any level of significance. In other words, there is no discernible existence of either the wealth effect or the credit price effect in these two markets; therefore, for both the UK and the Netherlands, although we find the credit price effect below the threshold, we can find neither the credit price effect nor the wealth effect above the threshold.

As regards the case of Spain, we find that there is some discernible bidirectional causality, generally referred to as 'feedback effect', in those cases where the wealth effect is found to exist above the threshold, and the credit price effect is found to exist below the threshold. These empirical results indicate that in the long run, the price transmissions between the two markets under examination are asymmetric. It is also interesting to note that the adjustment coefficients of Z^{+} and Z^{-} are markedly different for both markets.

Focusing on adjustments in the real estate market to restore equilibrium, the point estimates of the adjustment coefficients given in Table 2 indicate that, within the Netherlands, for a single unit positive change in the deviation from the equilibrium relationship created by a change in the stock price, there will be an adjustment of approximately 1.56 per cent in real estate prices. Conversely, real estate prices adjust by only −12.36 per cent of any negative change in the deviation from equilibrium created by a change in the stock price.

Nevertheless, we find that the adjustment process in the stock market is quite the reverse. In any given quarter, stock prices adjust so as to eliminate approximately −43.83 per cent (−1.96 per cent) of a unit negative (positive) change in the deviation from the equilibrium relationship created by changes in real estate prices. This finding indicates that adjustments towards a long-run equilibrium relationship between the real estate market and the stock market are much more rapid when the changes in the deviation are negative, as compared to when they are positive.

Indeed, the *F*-statistic also indicates that for the stock market of the Netherlands, the null hypotheses of $\rho_1 = \rho_2$ (i.e., where the coefficients of Z^{+} and Z^{-} are equal) is rejected. Thus, we find that when the differences in the previous disequilibrium term are above or below the threshold value of −0.115, the adjustments to the equilibrium level are asymmetric.

One particularly interesting finding of this study is that for most of the countries examined here, negative deviations from the real estate market to the stock market are much more rapid than positive deviations. Our interpretation of this is that, as measured by the TECM, in order to restore the long-run relationship within the system, over time, it appears to be the real estate (stock) prices that must bear the brunt of adjustment rather than the stock (real estate) prices when the threshold variable is above (below) the threshold value.

These empirical results further indicate that the price transmissions between these two markets are asymmetric. The results of our analysis of each country, from a long-term perspective, reveal the existence of the wealth effect on the relationship between real estate and stocks in Belgium, and the credit price effect on the relationship between real estate and stocks in the UK and the Netherlands. We also find the existence of a feedback effect between these two markets in both Spain and France.

4. Conclusions

The primary aim of this study is to investigate empirically the long-run equilibrium relationship that exists within European countries using the asymmetric threshold cointegration tests proposed by Enders and Granger (1998), and further developed by Enders and Siklos (2001). The M-TAR cointegration method provides strong evidence of a long-run equilibrium relationship characterized by asymmetric adjustment.

We find that within the European countries examined in this study, the dynamics towards long-run equilibrium follow non-linear adjustment. Furthermore, we also find that an asymmetric error-correction model can be used to investigate the movement of the variables from their long-run equilibrium relationship. The Granger causality test results clearly point to unidirectional causality running from the real estate market to the stock market (the credit price effect) in both the UK and the Netherlands. We also find unidirectional causality running from the stock market to the real estate market (the wealth effect) in Belgium, as well as the existence of feedback effects in both Spain and France.

We conclude that in the long run, asymmetric price transmissions do indeed exist between these two markets, both above and below the threshold. These findings consequently offer new evidence in support of the existence of long-run equilibrium relationships between the real estate market and the stock market, with asymmetric adjustment. This information could be made readily available to financial institutions and individual investors in European countries, to assist them in their construction of long-term investment portfolios within these two asset markets.

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